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THE
COMMERICAL HAND-BOOK
OF
CHEMICAL ANALYSIS ;

OR,
PRACTICAL INSTRUCTIONS FOR THE DETERMINATION OF THE INTRINSIC OR
COMMERCIAL VALUE OF SUBSTANCES USED IN MANUFACTURES,
IN TRADES, AND IN THE ARTS.

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" PRACTICAL INTRODUCTION TO ROSE'S CHEMISTRY," AND EDITOR OF ROSE'S "TREATISE OF
CHEMICAL ANALYSIS."

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COURSE OF GENERAL AND ANALYTICAL CHEMISTRY.

DR. NORMANDY'S practical course of General and of Analytical Chemistry, more particularly applied to the manufacturing arts and to agriculture, takes place at his Laboratory, every Wednesday and Saturday. An elementary course for new students begins every quarter, and continues on Tuesdays and Fridays, from 10 till 12 o'clock.

DR. NORMANDY gives private instruction on particular branches of Chemistry and Chemical Analysis, and may be consulted on patent and other cases requiring Chemical knowledge and research. Specifications are prepared or settled, and minerals, ores, soils, manures, &c., analyzed.

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P R E F A C E.

IF one of the principal characteristics of our epoch, in a commercial point of view, is the immense progress which every department of productive industry has achieved, it must be admitted that the arts of adulteration and sophistication have more than kept pace with that progress. These arts have invaded the luxuries and necessities of both the rich and the poor—raiment, food, medicine, furniture, the means of life, and the requirements of disease; all that can be mixed, hackled, twisted, ground, pulverized, woven, pressed—all articles of consumption in trade, in manufactures, in the arts, in a word, all that can be made matter of commerce and be sold, is adulterated, falsified, disguised, or drugged.

Yet it is necessary to make a distinction, for many things are denounced as adulterated, which, strictly speaking, are not so. For example, if by any contrivance a manufacturer succeed in making cloth or tissue in which a portion of wool, or of silk, or of linen, is replaced by cotton (and such fabrics are constantly made, as every one knows), such articles are improperly said to be spurious; it is simply a new fabric which partakes of certain properties of each material, and *when sold for what it is*, there can be no ground for com-

plaint; the public are clearly benefited by being able to procure articles answering the purpose and looking nearly, if not quite, as well as fabrics composed entirely of wool, silk, or linen, at a reduced price; and it is only when, on account of the close imitation, the seller succeeds in palming such articles on the unwary customer at, or nearly at, the price of the genuine goods that the practice is to be deprecated; but in such a case, the fraud clearly lies at the door of the seller, not at that of the maker. Neither are the goods to be inveighed against because dishonestly sold for that which they are not, that is under a false name, and at a price which they could not command if their nature were known.

When, however, sophistication is practised upon drugs or substances employed for manufacturing purposes, no such reasons can be pleaded, even in extenuation, for no benefit can possibly accrue to the public, even though the price be a reduced one, of an admixture of sulphate of barytes, or of chalk, for example, to white lead; of lamp-black to plum-bago; of sulphate of potash to sulphuric acid, &c., &c., and if adulteration be applied to medicinal agents, drugs, or ingredients, or to articles of food, the fraud becomes diabolical and unpardonable, for the addition of chalk, of plaster, of alum, to flour and to bread, of tallow and ochre to chocolate, of chromate of lead to tea, &c., not only affects the purchaser's purse, but destroys his health; whilst the substitution of flour for quinine, of clay or of Spanish liquorice for opium, of lead for mercury, of saltpetre for nitrate of silver, jeopardize at once the patient's life and the physician's name and character.

The public themselves, however, cannot, I think, be held altogether blameless of this extensive and widely-spread system of fraud and deception, of which albeit the sophisticators and their abettors bear all the odium. The morbid

appetite of numerous persons for *decided bargains*, the rage of cheapening, whatever be the price asked, have, if not created, at least increased the evil to an incredible extent. *Bargain-hunters* have therefore much to answer for in this and in other respects. But are we to pay a manufacturer, or a trader, just the price he chooses to ask? The answer is, that from the incessant competition amongst rival tradesmen, dealers, and producers, no article, generally speaking, can be long maintained above its fair selling price; and this same spirit of competition, which is strong enough to induce unprincipled dealers to resort to sophistication as a means of underselling their rivals in trade, is quite sufficient, and of itself works mischief enough, without any additional spur or incentive being given to it. I will illustrate my meaning by a familiar example:—

It is well known that, at the present moment, the average cost-price of coffee, including duty and roasting, is one shilling and two pence per pound, and yet we see it marked up for sale in a great number of shops at ONE SHILLING! What a bargain! But how does this come about? simply thus:—

	s.	d.
$\frac{1}{2}$ lb. of Coffee, at 1s. 2d. per lb.	0	7
$\frac{1}{2}$ lb. of Chicory, at 4d. per lb.	0	2
The Grocer's profit	0	3
1 lb. of adulterated Coffee	1	0

The purchaser has therefore paid one shilling for seven penny-worth of coffee. What a bargain! not to speak of the wretched beverage which the infusion will yield.

But so it is: in the struggle between quality and cheapness, the latter generally comes off victorious. Quality, in effect, can seldom be at once recognized or established except,

by *connaisseurs*, or by those who, being in the trade, are familiarized by long custom with the appearance or look, taste, odour, and other characteristics of the genuine article, and even those, notwithstanding their craft (such is the perfection of the adulterating arts), are often deceived. Besides, no one can be versed in every trade, and adulteration has invaded all. In most cases, therefore, a trial is necessary; but how few can make such a trial in a satisfactory manner, or know how to set about it? Cheapness, on the contrary, is understood at first sight; the temptation of purchasing a commodity cheap is enticing and cannot be withstood, it silences all other reasons, even the promptings of common sense, which point out that an article offered, without adequate reasons, and in the usual course of things, at or under prime cost, either cannot be genuine, or that the loss must be made up in some other way, and, doubt it not, at the bargainer's expense.

Whatever may be the cause of the development which the adulterating arts have taken, it is certain that if sophistication could be more readily detected, its practice would become less frequent, and be reduced in proportion to the increased chance of discovery; that is to say, it would diminish gradually as the knowledge of the means of ascertaining the commercial value of the goods offered for sale would become more diffused.

The object then of the present book is, it may be briefly stated, to indicate the various falsifications or the impurities which naturally, accidentally, or intentionally, may contaminate the various articles met with in commerce, and to enable the manufacturer, the miner, the trader, and the public generally, to detect the nature and amount of these sophistications and impurities, or, in other words, to ascertain the real or intrinsic value of such articles.

Hitherto this has been attained only by a regular analysis performed by the practical chemist. Several most valuable treatises of chemical analysis fully indicate, it is true, the methods by which such an analysis may be made, but these treatises, from the most complete downwards, are far too profound and elaborate to be of great use, except to the chemist or to the advanced chemical student; they require a previous competent knowledge of the science, and do not afford the slightest assistance to those who, not being very conversant with chemical matters, only wish to ascertain the purity or the actual amount of available matter contained in the substances manufactured or purchased by them.

In the same manner as a treatise of analytical chemistry indicates the methods by which compounds in general can be distinguished from each other, and their quantity determined, the "COMMERCIAL HAND-BOOK OF CHEMICAL ANALYSIS" is intended to show the specific application of these methods to compounds of a particular kind, and in which the operator may have to examine whether they are contaminated by impurities, or sophisticated by fraudulent additions, and to what extent; or, in fact, whether the constituents known to exist in the genuine article are present, and in the proper degree.

In order to facilitate research, all the substances treated of have been put in alphabetical order; and several of these compounds being known under various names, they have been entered under all these names in their respective order, the reader being at the same time referred to the more modern appellation for the information required.

The present book should have been published in November last, as announced in the prospectus. The short but unavoidable delay has been due to the introduction into the work of an additional number of articles, which have

increased its size above one-third more than was contemplated.

The reader, unlearned in chemical matters, will find at the end of this work a chapter devoted to the explanation of the Chemical Nomenclature, and of the rules, or laws, according to which bodies combine with each other, also a small Glossary of the terms employed in this book, and with which he may not be conversant.

In conclusion I would add, that all the apparatus, various instruments, and chemical re-agents, described in the pages of this work, may be obtained of the publishers.

The works which I have principally consulted are those of Berzelius's "*Traité de Chimie*," and "*Rapports Annuels sur les Progrès de la Chimie*;" H. Rose's "*Treatise of Chemical Analysis*;" J. B. Dumas's "*Traité de Chimie appliquée aux Arts et Manufactures*;" Fresenius's "*Chemical Analysis*;" Dr. Ure's "*Dictionary of Chemistry, and Dictionary of Arts, Manufactures, and Mines*;" C. Gerhart's "*Annuaire de Chimie*;" Bussy's and Bourton-Charlard's "*Traité des Falsifications des Drogues Simples*;" Garnier's and Harel's "*Des Falsifications des Substances Alimentaires*," &c.

A. NORMANDY.

67, Judd Street, Brunswick Square.

June 1850.

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ERRATA.

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- 94 7 lines from the bottom, instead of "12," read "192."
118 2 lines from the bottom, instead of "macerating," read "incinerating."
155 1st line, instead of "sulphate of "baryta," read "sulphate of lead."
270 and 271, running title, instead of "manganese," read "mercury."
326 3 lines from the bottom, instead of "0.24491," read "0.25;" and 5 lines from the bottom, instead of "90," read "128."
399 8 lines from the bottom, instead of "ferrocyanuret," read "ferricyanuret."
403 11 lines from the bottom, instead of "60," read "50;" and 17th line from the top, instead of "grammes," read "grains."
614 10 lines from the bottom, instead of "base," read "salt."

COMMERCIAL HAND-BOOK

OF

CHEMICAL ANALYSIS.

ACETATE OF COPPER.

SUBACETATE OF COPPER. VERDIGRIS. ÆRUGO.
VERDITER.

1. THE acetate of copper of commerce is a basic salt of copper, which is met with in lumps or cakes of about twenty-five pounds weight, packed up in white leather. This article which is extensively used by painters and dyers, and in medicine, is often adulterated to an enormous extent with *chalk* and with *sulphate of copper*.

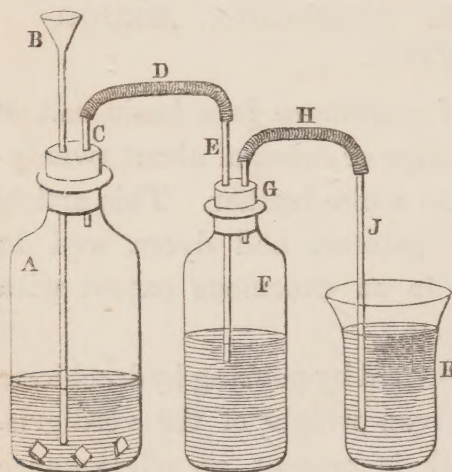
2. The presence of *chalk* is detected by pouring hydrochloric acid (muriatic acid) upon a given weight of the verdigris, previously pulverized. If chalk is present, an effervescence will take place, but if pure, the verdigris will dissolve in the acid without effervescing. Some impurities will, however, be left in an insoluble state, which should be collected on a filter, washed, dried, and weighed: in the genuine article their proportion should not exceed five or six per cent.

3. To the liquor filtered from the insoluble impurities above mentioned, solution of chloride of barium should be added; if this produces a white precipitate (sulphate of baryta), it is owing to the presence of sulphuric acid. The liquor containing the precipitate must be well shaken, and the precipitate

being separated by filtering should be washed, dried, ignited, and weighed; 117 grains of sulphate of baryta=40 grains of anhydrous sulphuric acid, and consequently 80 grains of anhydrous *sulphate of copper*, or 125 grains of this salt in crystals. See the note on Chemical Equivalents, at the end of the book.

4. In order to determine the proportion of *carbonate of lime*, a given weight of the verdigris, dissolved in hydrochloric, as above mentioned, should be treated by a current of sulphuretted hydrogen, until all the copper is precipitated in the state of sulphuret of copper.

5. This is done in the following manner: A is a bottle containing a few lumps of proto-sulphuret of iron, and provided with a perfectly air-tight cork, perforated with two holes, through one of which a funnel is introduced, and through the



other hole a short straight glass tube, C, protrudes, which is connected by means of a tube of vulcanized caoutchouc D, with another glass tube E, which passes through a hole in the cork of bottle F, containing water, and into which water that tube E plunges about one inch deep; through another hole in the cork of bottle F,

a short straight tube of glass, G, is connected by means of a tube of caoutchouc, H, with a disengagement straight glass tube J, which is immersed in the beaker K, containing the solution of acetate of copper under examination. Sulphuric acid, diluted with water, being poured through the funnel B, into the bottle A, containing proto-sulphuret of iron, a copious stream of sulphuretted hydrogen is immediately evolved. All the joints should, of course, be perfectly air-tight. The water in the bottle F serves to wash the gas.

6. The stream of sulphuretted hydrogen should be passed

through the solution of acetate of copper until the latter smells strongly of the gas, even after shaking it well. The black precipitate of sulphuret of copper so produced is separated by filtering, and washed. The filtrate is then neutralized by ammonia, and treated by oxalate of ammonia, which will then precipitate the lime in the state of oxalate of lime. This precipitate is collected on a filter, washed, dried, and ignited, that is, heated to redness in a small platinum crucible. Ignition converts it into carbonate of lime, and it is then weighed as such.

7. Pure verdigris is completely soluble, not only in hydrochloric acid, but likewise in ammonia, and with the help of heat in dilute sulphuric acid.

8. The buyers of this article generally judge of its value by the brightness of its colour, and by its dryness: by rubbing it in the palm of the hand with a little water or saliva, it should form a smooth paste free from grittiness.

9. The best verdigris is made at Montpellier in France. The English verdigris is made from the refuse of cyder, and is much inferior to the French.

ACETATE OF LEAD.

SUGAR OF LEAD. SALT OF SATURN.

1. Acetate of lead is used in various arts, especially in dying and calico printing, and is on that account an important article of commerce. The salt is generally met with in white acicular crystalline lumps of a sweet astringent flavour.

2. The acetate of lead of commerce sometimes contains acetate of lime, the presence of which, however, may be detected by dissolving a portion of the sample in water, passing a stream of sulphuretted hydrogen gas—(see apparatus, page 7) through the solution, in order to precipitate the whole

of the lead in the state of sulphuret (black), filtering and testing the filtrate with a solution of oxalic acid, or of binoxalate of potash, or, better still, of oxalate of ammonia, which will then produce a precipitate of oxalate of lime. Instead of adding a solution of oxalate of ammonia, a solution of oxalic acid may be first poured into the filtrate, and an excess of aqueous ammonia being then added, will produce a white precipitate of oxalate of lime, if that earth be present. Whichever way the precipitate is produced, the liquid containing it should be warmed, and then left at rest until all the precipitate has well settled; it is then collected on a filter, washed, dried, and moderately ignited in a platinum crucible. The oxalate of lime at first burns with a blue flame owing to the oxyde of carbon produced; the mass becomes greyish, then white, the ignition having now converted it into carbonate of lime, in which state it is weighed after cooling. 50 grains of carbonate of lime represent 28 of lime, and consequently 79 of acetate of lime.

3. If, after saturating the filtrate with ammonia the liquor becomes blue, it is owing to the presence of copper; if it remains colourless but becomes black by the further addition of hydrosulphuret of ammonia, it is owing to the presence of iron. The proportion of these impurities, however, is generally very trifling.

ACETATE OF SODA.

1. This salt is of importance as being the principal source from which acetic acid, in a more or less purified state, is obtained for several processes in the arts. It is often contaminated by sulphate of soda, and by chloride of sodium (common salt,) or of potassium.

2. The presence of sulphate of soda may be detected and estimated by means of solution of chloride of barium, in the following manner: a given weight of the salt is to be

dissolved in water, and the solution being tested by one of chloride of barium, a white precipitate of sulphate of baryta will then be produced, which should be collected on a filter, washed, dried, ignited, and weighed.—117 gr. of sulphate of baryta=72 of sulphate of soda.

3. Chloride of sodium, or of potassium, if present, may be precipitated by pouring into the solution of the acetate of soda above mentioned, some solution of nitrate of silver, until a precipitate ceases to be formed. The liquor containing the precipitate (which is chloride of silver) should be slightly heated, after which the latter is collected on a small filter, washed, dried, fused in a porcelain crucible, and then weighed. 144 gr. of chloride of silver=60 gr. of chloride of sodium, and 66 gr. of chloride of potassium.

4. Pure acetate of soda is white, and neutral when tried by test papers; it dissolves in 2.86 parts of cold water, and in 5 parts of alcohol.

ACETIC ACID.—See *Vinegar*.

ACIDIMETRY.

1. The process by which the quantity of real acid contained in acids, and consequently their intrinsic value, is ascertained, is called *acidimetry*. One of the most convenient methods of effecting this object is that first proposed by Dr. Ure, by means of an aqueous solution of pure ammonia of a standard strength, faintly tinged with litmus. The strength of the aqueous ammonia should be so adjusted, that 1000 grains-measure of it contain exactly one equivalent (17 grains) of ammonia, and consequently neutralize exactly one equivalent of any real acid. The specific gravity of the pure water of ammonia employed as test for the purpose should be 0.992; and 1000 grains-measure (100 divisions of the alkalimeter) will then neutralize exactly—

- 40 grains of sulphuric acid (anhydrous),
 37 do. of muriatic acid gas,
 54 do. of nitric acid,
 60 do. of crystalized acetic acid, &c.

and so forth with the other acids.

2. An aqueous solution of ammonia of the above strength and gravity being prepared, the acidimetical process is very similar to that practised in alkalimetry—that is to say, a known weight, for example 100 grains of the sample of acid to be examined, are poured into a sufficiently large glass vessel and diluted, if need be, with water; 1000 grains-measure of the test liquor of ammonia, slightly tinged blue with tincture of litmus, are then poured into an acidimeter divided into 100 divisions. [An alkalimeter of course can be employed for both acidimetical and alkalimetical experiments, the only difference being in the test liquor employed as test, which in the present case is solution of ammonia of a known strength, whilst in alkalimetry the test liquor is a sulphuric acid also of a known strength.—See *Alkalimetry*.] The operator then proceeds to pour the test liquor of ammonia from the acidimeter into the acid under examination, until the change of colour (from blue to red) of the test liquor of ammonia, and trials with litmus paper (see *Alkalimetry*) indicate that the neutralization is complete.

3. Let us suppose that 100 grains in weight of a sample of sulphuric acid for example, have required 60 divisions (600 grains-measure) of the test liquor of ammonia above alluded to, for their complete neutralization; then the proportion is,—

$$100 : 40 :: 60 : x = 24.$$

4. The sulphuric acid examined contained, therefore, 24 per cent. of pure anhydrous sulphuric acid, or 24 of dry acid, plus 5.4 of water, that is 29.4 of pure mono-hydrated sulphuric acid.

5. In the same manner, suppose that 100 grains weight of hydrochloric acid (muriatic acid) have required 42 divisions

(420 grains-measure) of the acidimeter for their complete neutralization, the equivalent of hydrochloric acid gas being 37, the proportion is,—

$$100 : 37 :: 42 = x \ 15.54.$$

The hydrochloric acid examined contained therefore 15.54 per cent. of pure or dry hydrochloric acid gas.

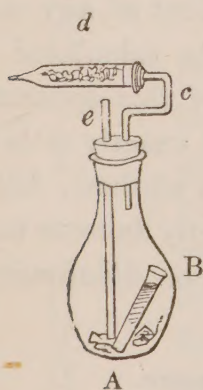
6. This method is extremely convenient, both on account of its great accuracy, and the rapidity with which the analysis may be performed; a few minutes only are required to determine the quantity of real acid which may thus be estimated, even to one-fiftieth part of a grain.

7. Instead of liquor of ammonia of the above gravity, a solution containing one equivalent of another base, carbonate of soda for example, may be used, thus:—

8. Take 10,000 grains-measure of distilled water and dissolve therein 540 grains of dry or anhydrous carbonate of soda obtained by igniting the bicarbonate of that base; 1000 grains-measure (100 alkalimetical measures) of such a solution correspond therefore to one equivalent of any acid.

9. The strength of acids may also be ascertained by determining the weight of carbonic acid which a given quantity of acids expels from a known weight of bicarbonate of potash, or of soda. This is done as follows:—

10. The operator takes a bottle A, which has a somewhat wide mouth, but which is capable of being her-



metically closed by a cork perforated with two holes, through one of which a bent tube *c*, passes, and is connected with another larger tube *d*, filled with fused chloride of calcium; through the other hole a tube *e* is introduced sufficiently long to reach the bottom of the bottle A. The cork with its two tubes, one of which is filled with chloride of calcium, is then accurately weighed.

11. A larger quantity of bicarbonate of soda than is

required for saturation is then introduced into the bottle A, and a small vessel (a glass tube closed at one end answers best) is then filled with a weighed quantity of the acid to be examined, and is also put into the bottle A, taking care that the acid does not come in contact with the bicarbonate of soda, which is easily avoided by putting the tube containing the acid in an upright position, and leaning against the sides of the bottle A, and the whole is accurately weighed. The bottle is then to be closed with the cork prepared as above directed, and the apparatus is shaken or gently jerked so as to upset the tube B containing the acid. A disengagement of carbonic acid immediately takes place from the decomposition of the bicarbonate of soda by the acid; the water which is mechanically carried off by the carbonic acid condenses, or is absorbed by the fused chloride of calcium in the tube *d*. When all disengagement of carbonic acid has ceased, even after shaking the apparatus, the bottle A should be plunged into a water bath heated to above 100° Fahrenheit, whilst the operator sucks up at *f* the carbonic acid gas contained in the bottle, and which is then replaced by the air which enters by the tube *e*. The apparatus should now be wiped dry, and after cooling; it is weighed, the loss of weight indicates the quantity of carbonic acid expelled, and consequently the saturating power of the acid employed; 44 grains of loss represent 40 grains of dry sulphuric acid, 37 grains of dry hydrochloric acid gas, or one equivalent of any other acid, from which the per centage is easily calculated by a simple rule of proportion. Or, instead of this apparatus, that of Drs. Fresenius and Will may be used exactly as is described for the estimation of alkalies by that method; but in either case the balance used should be sufficiently delicate to indicate small weights when heavily laden.—See *Alkalimetry*.

ÆRUGO.—See *Acetate of Copper*.

ALBATA.—See *German Silver*.

ALCOHOL.

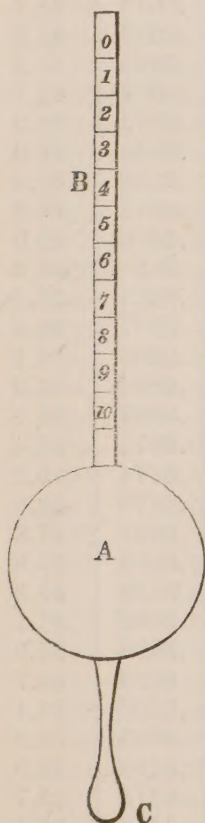
SPIRITS OF WINE—SPIRITS.

1. The spirits of wine of commerce is essentially a mixture of alcohol and water, which contains besides a very small proportion of a peculiar oil derived from the substances from which the spirit has been obtained.

2. The proportion of alcohol contained in spirits of wine, or its *strength*, is generally ascertained by its specific gravity, which is best determined by means of a delicate balance, but for which purpose an instrument called the *hydrometer*, or *alcoholmeter*, is more generally employed on account of the facility of its application, and of the rapidity with which the experiment can be performed. There are several forms of hydrometers, but the instrument always consists of a hollow

bulb of glass or of metal, with a counterpoise below it, and a slender stem above, divided into a certain number of degrees. A set of tables is generally sold with the instrument, by consulting which the specific gravity of the spirit is easily ascertained, after observing the degree, upon the stem, to which the instrument sinks on being immersed in the spirits under examination.

3. The following figure represents Sikes's Hydrometer. That instrument consists of a brass ball A, through which a flat stem B passes, loaded at C, and which is divided into 11 equal parts, each of which is subdivided into two parts. Eight weights are sold with the instrument, which serve for determining the gravity of liquids which are heavier than water.



4. The mixture of alcohol and of water in such proportions,

that at 60° Fahr. it has a specific gravity of 0.92, is called *standard*, or *proof spirit*, and it consists of about equal parts, by weight, of pure alcohol and of water. We reproduce here a table taken from Dr. Ure's Supplement to his Dictionary of Arts, Manufactures, and Mines.

5. Correspondence between specific gravity and per cents. over proof at 60° Fahr.

Specific Gravity.	Per Cent. Over Proof.	Specific Gravity.	Per Cent. Over Proof.	Specific Gravity.	Per Cent. Over Proof.	Specific Gravity.	Per Cent. Over Proof.
0.8156	67.0	.8301	59.8	.8445	52.3	.8583	43.9
.8160	66.8	.8305	59.6	.8448	52.1	.8587	43.7
.8163	66.6	.8308	59.5	.8452	51.9	.8590	43.5
.8167	66.5	.8312	59.3	.8455	51.7	.8594	43.3
.8170	66.3	.8315	59.1	.8459	51.5	.8597	43.1
.8174	66.1	.8319	58.9	.8462	51.3	.8601	42.8
.8178	65.6	.8322	58.7	.8465	51.1	.8604	42.6
.8181	65.8	.8326	58.6	.8469	50.9	.8608	42.4
.8185	65.6	.8329	58.4	.8472	50.7	.8611	42.2
.8188	65.5	.8333	58.2	.8476	50.5	.8615	42.0
.8192	65.3	.8336	58.0	.8480	50.3	.8618	41.7
.8196	65.1	.8340	57.8	.8482	50.1	.8622	41.5
.8199	65.0	.8344	57.7	.8486	49.9	.8625	41.3
.8203	64.8	.8347	57.5	.8490	49.7	.8629	41.1
.8206	64.7	.8351	57.3	.8493	49.5	.8632	40.9
.8210	64.5	.8354	57.1	.8496	49.3	.8636	40.6
.8214	64.3	.8358	56.9	.8499	49.1	.8639	40.4
.8218	64.1	.8362	56.8	.8503	48.9	.8643	40.2
.8221	64.0	.8365	56.6	.8506	48.7	.8646	40.0
.8224	63.8	.8369	56.4	.8510	48.5	.8650	39.8
.8227	63.6	.8372	56.2	.8513	48.3	.8653	39.5
.8231	63.4	.8376	56.0	.8516	48.0	.8657	39.3
.8234	63.2	.8379	55.9	.8520	47.8	.8660	39.1
.8238	63.1	.8383	55.7	.8523	47.6	.8664	38.9
.8242	62.9	.8386	55.5	.8527	47.4	.8667	38.7
.8245	62.7	.8390	55.3	.8530	47.2	.8671	38.4
.8249	62.5	.8393	55.1	.8533	47.0	.8674	38.2
.8252	62.3	.8396	55.0	.8537	46.8	.8678	38.0
.8256	62.2	.8400	54.8	.8540	46.6	.8681	37.8
.8259	62.0	.8403	54.6	.8543	46.4	.8685	37.6
.8263	61.8	.8407	54.4	.8547	46.2	.8688	37.3
.8266	61.6	.8410	54.2	.8550	46.0	.8692	37.1
.8270	61.4	.8413	54.1	.8553	45.8	.8695	36.9
.8273	61.3	.8417	53.9	.8556	45.6	.8699	36.7
.8277	61.1	.8420	53.7	.8560	45.4	.8702	36.4
.8280	60.9	.8424	53.5	.8563	45.2	.8706	36.2
.8284	60.7	.8427	53.3	.8566	45.0	.8709	35.9
.8287	60.5	.8431	53.1	.8570	44.8	.8713	35.7
.8291	60.4	.8434	52.9	.8573	44.6	.8716	35.5
.8294	60.2	.8438	52.7	.8577	44.4	.8720	35.2
.8298	60.0	.8441	52.5	.8581	44.2	.8723	35.0

Specific Gravity.	Per Cent Over Proof	Specific Gravity.	Per Cent. Over Proof.	Specific Gravity.	Per Cent. Over Proof.	Specific Gravity.	Per Cent. Under Prf.
.8727	34.7	.8908	22.2	.9697	8.3	.9282	7.0
.8730	34.5	.8912	21.9	.9100	8.0	.9286	7.3
.8734	34.3	.8915	21.7	.9104	7.7	.9291	7.7
.8737	34.1	.8919	21.4	.9107	7.4	.9295	8.0
.8741	33.8	.8922	21.2	.9111	7.1	.9299	8.3
.8744	33.6	.8926	20.9	.9115	6.8	.9302	8.6
.8748	33.4	.8930	20.6	.9118	6.5	.9306	9.0
.8751	33.2	.8933	20.4	.9122	6.2	.9310	9.3
.8755	32.9	.8937	20.1	.9126	5.9	.9314	9.7
.8758	32.7	.8940	19.9	.9130	5.6	.9318	10.0
.8762	32.4	.8944	19.6	.9134	5.3	.9322	10.3
.8765	32.2	.8948	19.3	.9137	5.0	.9326	10.7
.8769	32.0	.8951	19.1	.9141	4.8	.9329	11.0
.8772	31.7	.8955	18.8	.9145	4.5	.9332	11.4
.8776	31.5	.8959	18.6	.9148	4.2	.9337	11.7
.8779	31.2	.8962	18.3	.9152	3.9	.9341	12.1
.8783	31.0	.8966	18.0	.9156	3.6	.9345	12.4
.8786	30.8	.8970	17.7	.9159	3.3	.9349	12.8
.8790	30.5	.8974	17.5	.9163	3.0	.9353	13.1
.8793	30.3	.8977	17.2	.9167	2.7	.9357	13.5
.8797	30.0	.8981	16.9	.9170	2.4	.9360	13.9
.8800	29.8	.8985	16.6	.9174	2.1	.9364	14.2
.8804	29.5	.8989	16.4	.9178	1.9	.9368	14.6
.8807	29.3	.8992	16.1	.9182	1.6	.9372	14.9
.8811	29.0	.8996	15.9	.9185	1.3	.9376	15.3
.8814	28.8	.9000	15.6	.9189	1.0	.9380	15.7
.8818	28.5	.9004	15.3	.9192	0.7	.9384	16.0
.8822	28.3	.9008	15.0	.9196	0.3	.9388	16.4
.8825	28.0	.9011	14.8	.9200	Proof.	.9392	16.7
.8829	27.8	.9015	14.5	Under Proof.		.9396	17.1
.8832	27.5	.9019	14.2	.9204	0.3	.9399	17.5
.8836	27.3	.9023	13.9	.9207	0.6	.9403	17.8
.8840	27.0	.9026	13.6	.9210	0.9	.9407	18.2
.8843	26.8	.9030	13.4	.9214	1.3	.9411	18.5
.8847	26.5	.9034	13.1	.9218	1.6	.9415	18.9
.8850	26.3	.9038	12.8	.9222	1.9	.9419	19.3
.8854	26.0	.9041	12.5	.9226	2.2	.9422	19.7
.8858	25.8	.9045	12.2	.9229	2.5	.9426	20.0
.8861	25.5	.9049	12.0	.9233	2.8	.9430	20.4
.8865	25.3	.9052	11.7	.9237	3.1	.9434	20.8
.8869	25.0	.9056	11.4	.9241	3.4	.9437	21.2
.8872	24.8	.9060	11.1	.9244	3.7	.9441	21.6
.8876	24.5	.9064	10.8	.9248	4.0	.9445	21.9
.8879	24.3	.9067	10.6	.9252	4.4	.9448	22.2
.8883	24.0	.9071	10.3	.9255	4.7	.9452	22.7
.8886	23.8	.9075	10.0	.9259	5.0	.9456	23.1
.8890	23.5	.9079	9.7	.9263	5.3	.9460	23.5
.8894	23.2	.9082	9.4	.9267	5.7	.9464	23.9
.8897	23.0	.9085	9.2	.9270	6.0	.9468	24.3
.8901	22.7	.9089	8.9	.9274	6.4	.9472	24.7
.8904	22.5	.9093	8.6	.9278	6.7	.9476	25.1

Specific Gravity.	Per Cent. Under Pr f.	Specific Gravity.	Per Cent. Under Prf.	Specific Gravity.	Per Cent. Under Prf.	Specific Gravity.	Per Cent. Under Prf.
.9480	25.5	.9611	41.1	.9742	61.8	.9874	83.5
.9484	25.9	.9615	41.7	.9746	62.5	.9878	84.0
.9488	26.3	.9619	42.2	.9750	63.2	.9882	84.6
.9492	26.7	.9623	42.8	.9754	63.9	.9886	85.2
.9496	27.1	.9627	43.3	.9758	64.6	.9890	85.8
.9499	27.5	.9631	43.9	.9762	65.3	.9894	86.3
.9503	28.0	.9635	44.4	.9766	66.0	.9898	86.9
.9507	28.4	.9638	45.0	.9770	66.7	.9902	87.4
.9511	28.8	.9642	45.5	.9774	67.4	.9906	88.0
.9515	29.2	.9646	46.1	.9778	68.0	.9910	88.5
.9519	29.7	.9650	46.7	.9782	68.7	.9914	89.1
.9522	30.1	.9654	47.3	.9786	69.4	.9918	89.6
.9526	30.6	.9657	47.9	.9790	70.1	.9922	90.2
.9530	31.0	.9661	48.5	.9794	70.8	.9926	90.7
.9534	31.4	.9665	49.1	.9798	71.4	.9930	91.2
.9539	31.1	.9669	49.7	.9802	72.1	.9934	91.7
.9542	32.3	.9674	50.3	.9806	72.8	.9938	92.3
.9546	32.8	.9677	51.0	.9810	73.5	.9942	92.8
.9550	33.2	.9681	51.6	.9814	74.1	.9946	93.3
.9553	33.7	.9685	52.2	.9816	74.8	.9950	93.8
.9557	34.2	.9689	52.9	.9822	75.4	.9954	94.3
.9561	34.6	.9693	53.3	.9826	76.1	.9958	94.9
.9565	35.1	.9697	54.2	.9830	76.7	.9962	95.4
.9569	35.6	.9701	54.8	.9834	77.3	.9966	95.9
.9573	36.1	.9705	55.5	.9838	78.0	.9970	96.4
.9577	36.6	.9709	56.2	.9842	78.6	.9974	96.8
.9580	37.1	.9713	56.9	.9846	79.2	.9978	97.3
.9584	37.6	.9718	57.6	.9850	79.8	.9982	97.7
.9588	38.1	.9722	58.3	.9854	80.4	.9986	98.2
.9592	38.6	.9726	59.0	.9858	81.1	.9990	98.7
.9596	39.1	.9730	59.7	.9862	81.7	.9993	99.1
.9599	39.6	.9734	60.4	.9866	82.3	.9997	99.6
.9603	40.1	.9738	61.1	.9870	82.9	1.0000	1.000
.9607	40.6						

6. As spirits of wine is an excisable article charged with a heavy duty, proportionate to its strength, and the manufacture or distillation of which is fettered by very stringent regulations, it is often adulterated in various ways ; such as, by an addition of sugar, or of extractive matter, by which its apparent strength is diminished ; or by turpentine, coal and wood naphtha, pyrolignous acid, which are sometimes fraudulently added in sufficient quantity to enable the article to pass under the name of one or the other of these substances, and thus to escape the duty.

7. If sugar, extractive matter, or turpentine, have been added,

the best way of ascertaining the quantity of alcohol present, consists in distilling a portion of the sample, and taking the specific gravity of the distilled portion, which on referring to the table above, will indicate the per centage of alcohol.

8. The admixture of alcohol to wood naphtha, or rather that of a small quantity of wood naphtha, or of pyrolignous acid to a large proportion of alcohol, is a fraud which has been exploded by Dr. Ure, who, having examined, at the request of the Board of Customs, samples of certain parcels of goods, represented as being wood-naphtha, and which had been at first detained on suspicion, succeeded in establishing that the so-called wood-naphtha consisted almost entirely of alcohol, slightly disguised by a small proportion of pyrolignous acid.

9. The process recommended by Dr. Ure, for the detection of alcohol in wood-spirit, is as follows :

10. "A small quantity of nitric acid of specific gravity 1.45, is first to be added to the spirit under examination, which, if alcohol is present, will immediately produce an effervescence of nitrous ether gas, which may be recognized as such by its odour. The mixture is then treated by a solution of mercury in nitric acid (which is prepared by dissolving 100 gr. of mercury in one fluid ounce of nitric acid, with the help of heat). Soon after this addition, and especially with the help of a gentle heat, the mixture begins to effervesce and to evolve thick ethereal vapours; should the effervescence become too tumultuous or violent, it must be quelled by immediately withdrawing the fire, and cooling the vessel. A yellowish grey precipitate falls down, which is fulminate of mercury, and which should be immediately separated by decanting or filtering the liquor from it, washing the precipitate on the filter with a little distilled water, and carefully drying it at a heat which must not exceed 100° Fahr.; after which it is weighed. The quantity of fulminate of mercury obtained is nearly equal to that of the alcohol contained in the wood-spirit; and, at any rate, the formation of the detonating salt is quite characteristic of the presence of

alcohol, since wood-spirit, treated by nitric acid and mercury or silver, can produce no fulminate of silver or of mercury."

11. "The operator will bear in mind that fulminate of mercury and fulminate of silver are dangerously explosive compounds, which should be handled with the utmost caution, especially the fulminate of silver. In collecting that substance, it should not be touched with any thing hard, for fulminate of silver has been known to explode by contact with a glass rod, even under water. Fulminate of mercury, however, explodes less readily, and should be preferred. For the purpose of collecting these compounds, the feather of a quill should be used; and if the quantity is at all considerable, that is, if it exceeds a few grains, it should be collected in several filters, so as to handle only small portions at a time. During the evolution of the ethereal vapours, above alluded to, all approach of flame should be carefully avoided."

12. According to Dr. Ure, the best criteria for distinguishing wood naphtha from alcohol, and ascertaining whether the former is genuine, or illegally mixed with alcohol, are the following:—

13. 1st. The boiling point of pure wood-naphtha-spirit is at least 20° Fahr. below that of alcohol of the same gravity, and it exhales the characteristic pungent and offensive odour of aldehyde. Thus Dr. Ure found the boiling point of pure wood-spirit and of pure alcohol to be as follows:—

<i>Sp. gr.</i>	0.870.	<i>Boiling point of wood-spirit</i>		144° Fahr.	<i>of alcohol</i>	180° Fahr.
<i>do.</i>	0.832.	<i>do.</i>	<i>do.</i>	140°	<i>do.</i>	171.5

If 10 per cent. of naphtha be mixed with alcohol, the boiling point is lowered at least 6° Fahr.

14. 2ndly. When rectified naphtha of sp. gr. 0.870 is distilled along with a great quantity of unslaked, powdered quick lime in a retort plunged in boiling water, the spirit comes over with its gravity unchanged; whereas, if genuine alcohol or a mixture of alcohol with naphtha be distilled in the same way, the distilled portion is nearly free from water, and of a

gravity under 0.800 or 70 per cent. over proof at the temperature of 60° Fahr.; wood-spirit having apparently a greater affinity for water than alcohol.

15. 3rdly. When water is added to alcohol, the specific gravity of the liquor becomes reduced in a greater proportion than when wood-spirit of the same gravity as the alcohol is diluted with the same quantity of water. Thus, for example, if alcohol of a given density is diluted with a certain quantity of water so as to bring it to sp. gr. 0.920, wood-spirit of the same original gravity, and diluted with the same quantity of water, will become of sp. gr. 0.926 or 0.927.

16. Dr. Ure says that caustic potash in powder is the most delicate test for the detection of wood-spirit in alcohol, for if wood-spirit is present the liquor assumes then a brown colour, whilst pulverized potash does not alter the colour of pure alcohol, even after several hours, and it is only after a whole day's contact that a feeble yellowish tinge is then developed. But if the alcohol contains only 2 per cent., or even 1 per cent. of wood-spirit, it turns yellowish in the course of ten minutes, and brown in half an hour.

17. The specific gravity of perfectly pure alcohol is from 0.792 to 0.800; but by mere distillation the stronger spirit does not yield alcohol of a less specific gravity than 0.820. The alcohol of shops never exceeds 0.835 or 0.840. See *Brandy*.

ALE.—See *Beer*.

ALIZARI.—See *Madder*.

ALKALIMETRY.

1. The object of alkalimetrical operations is to determine the quantity of caustic alkali, or of carbonate of alkali, contained in the potash or soda of commerce. These operations are simple, accurate, rapid, and easy; they may be said to consist in pouring on a weighed portion of the sample of potash or of soda under examination, a certain

quantity of an acid of a known strength, until the alkali is saturated, that is to say, until the neutralizing point is hit, which is ascertained by means of litmus paper as will be described presently.

Fig. 1. The instrument from which the name of this method of analyzing alkalies is derived, is called an *alkalimeter*. Figure 1 represents Gay Lussac's alkalimeter; it is a glass tube about 14 inches high, and half an inch in diameter, capable of holding more than 1000 grains of water. It is graduated accurately from the top downwards, into 100 divisions, in such a way that each division contains 10 grains of water. It has a small tube *b*, communicating with the larger one, which small tube is bent and bevelled at the top, *c*. This very ingenious instrument was contrived by Gay Lussac, and is by far more convenient than the ordinary alkalimeter, as by it the test acid may be unerringly poured, drop by drop, as wanted. The only drawback to Gay Lussac's alkalimeter is the fragility of the small side tube, *b*, on which

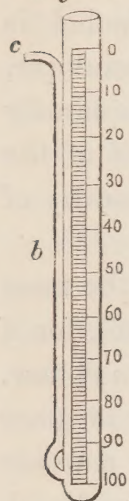
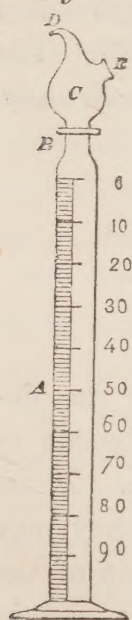


Fig. 2.

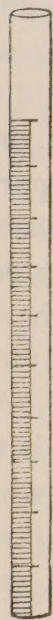


account the common alkalimeter, fig. 3, (see *infra*) is more generally used, because, as it has no side tube, it is not liable to be so easily broken; but then it is less manageable, requires greater steadiness of hand, and does not give such accurate results, a portion of the test-acid being often wasted in various ways. Gay Lussac's alkalimeter, therefore, is preferable; and if melted sealing wax be run, or gutta percha pressed into the interstice between the small and the large tube, the instrument is thereby rendered much less fragile.

2. The following form of alkalimeter represented here, which I contrived some time ago, and which is a modification of Schuster's alkalimeter, will, I think, be found more convenient still than

that of Gay Lussac. It consists of a glass-tube, A, of the same dimensions, and graduated in the same manner as that of Gay Lussac; but it is provided with a glass foot, and the upper part, B, is shaped like the neck of an ordinary glass bottle. C is a bulb blown from a glass tube, one end of which is ground to fit the neck, B, of the alkalimeter, like an ordinary glass stopper. This bulb is drawn to a capillary point at D, and has a somewhat large opening at E. With this instrument the acid test-liquor is perfectly under the control of the operator, for the globular joint at top enables him to see the liquor before it actually begins to drop out, and he can then regulate the pouring to the greatest nicety, whilst its more substantial form renders it much less liable to accidents than that of Gay Lussac. The glass-foot is extremely convenient, and is at the same time a great additional security. See No. 35.

Fig. 3.



3. When the common alkalimeter, fig. 3, is used, the operator must carefully pour the acid from it, by closing the tube with his thumb, so as to allow the acid to trickle in drops as occasion may require; and it is well also to smear the lip of the tube with tallow, in order to prevent any portion of the test-acid from being wasted by running over the outside, after pouring, which accident would, of course, render the analysis altogether inaccurate and worthless; and for the same reason, after having once begun to pour the acid from the alkalimeter, by allowing it to trickle between the thumb and the lip of the tube, as above mentioned, the thumb must not be removed from the tube till the end of the experiment, for otherwise the portion of acid which adheres to it would, of course, be wasted, and vitiate

the result. With either of the alkalimeters, figs. 1 and 2, this uncomfortable precaution is not required, the acid falling naturally, drop by drop, from the small tube, by inclining the alkalimeter.

4. There are several other forms of alkalimeter, such as those of Dr. Ure, Mr. Jamieson, and others, but whichever kind is chosen, the process is the same: namely, pouring carefully the acid into the solution of the alkali under examination until the neutralizing point is obtained, as will be shown presently.

PREPARATION OF THE TEST-ACID FOR POTASH.

5. The test-acid generally preferred in alkalimetical assays is sulphuric acid of such a strength that each division (or 10 grains-measure) of the alkalimeter saturates exactly one grain of pure potash. An acid of that particular strength is prepared as follows:—

6. Take 112.4 grains of pure neutral and anhydrous carbonate of soda, and dissolve them in about five ounces of hot water. [Anhydrous, that is dry, neutral carbonate of soda, may be made by keeping a certain quantity of pure bicarbonate of soda, for a short time, at a dull heat, in a platinum crucible, by which means it is converted into the neutral carbonate, free from water.] This quantity, namely 112.4 grains of neutral carbonate of soda, will saturate exactly the same quantity of sulphuric acid that 100 grains of pure potash would. Mix now one part, by measure, of concentrated sulphuric acid with 10 parts, by measure, of water, and as it is advisable, where alkalimetical assays have frequently to be made, to keep a stock of test-acid, mix 1000 grains-measure of concentrated sulphuric acid, with 10,000 grains-measure of water, stir the whole well, and allow it to cool. When quite cold, fill the graduated alkalimeter with the cold diluted acid, just mentioned, up to the point marked 0° , taking the under line of the liquid as the true level, and whilst stirring briskly with a glass rod the aqueous solution of the 112.4 grains of neutral carbonate of soda above alluded to, drop the acid from the alkalimeter into the vortex produced by stirring, until by testing the alkaline solution with a strip of reddened litmus paper, after each addition of acid,

it is found that it no longer shows an alkaline reaction, (which is known by the strip of reddened litmus paper not being rendered blue,) but on the contrary, indicates that a very slight excess of acid is present, (which is known by testing with blue litmus paper, which will then turn *faintly* red.)

7. If after having thus exhausted *the whole* of the 100 divisions (1000 grains-measure) of the diluted acid in the alkalimeter, the neutralization is found to be exactly attained, it is a proof that the test-acid is right.

8. But suppose, on the contrary, that only 80 divisions of the acid in the alkalimeter have been required to neutralize the alkaline solution, it is then a proof that the test-acid is too strong, it must therefore be further diluted with water, to bring it to the standard strength, which is done by adding 20 measures of water to every 80 measures of the acid. This is best accomplished by pouring the whole of the acid into a large glass-cylinder, accurately divided into 100 parts, until it reaches the scratch or mark corresponding to 80 measures; the rest of the glass, up to 100, is then filled up with water, so that the same quantity of real acid will now be in the 100 measures, as was contained before in 80 measures.

9. The above test-acid being thus adjusted for the alkalimetical assay of potash may be labelled *test sulphuric acid for potash*. Each degree or division of the alkalimeter of such an acid represents one grain of pure potash.

10. When a stock of test-acid has been thus prepared, it should be kept in well-stoppered flasks, otherwise evaporation taking place would increase the quantity of acid in the remaining bulk, and, of course, render it valueless as a test-acid until re-adjusted.

PREPARATION OF THE TEST-ACID FOR SODA.

11. Like for potash, the test-acid generally preferred in alkalimetical assays of soda is sulphuric acid, but it must be so adjusted that 100 divisions (1000 grains-measure) of acid

will exactly neutralize 16.87 of pure anhydrous neutral carbonate of soda, that quantity containing exactly 100 grains of pure soda.

12. Dissolve, therefore, 168.7 grains of pure anhydrous neutral carbonate of soda (obtained as indicated before, see No. 6) in five or six ounces of hot water, and prepare in the meantime the test sulphuric acid by mixing one part by measure of concentrated sulphuric acid with about 9 parts by measure of water, and stir the whole thoroughly. When the mixture has become quite cold, pour 1000 grains-measure of the acid into the alkalimeter, that is to say, fill the alkalimeter with the diluted acid up to the point marked 0° , taking the under line of the liquid as the true level, and then, whilst stirring briskly the aqueous solution of the 168.7 grains of carbonate of soda with a glass rod, pour the acid carefully and drop by drop from the alkalimeter into the vortex so produced, until by testing the liquor alternately with reddened and with blue litmus paper (see No. 6), the exact neutralization is obtained.

13. If the whole of the 100 divisions (1000 grains-measure) have been required to effect the neutralization, it is a proof that the acid is of the right strength; but if this is not the case it must be adjusted as described before (see No. 8), that is to say :—

14. Suppose, for example, that only 75 divisions or measures of the acid in the alkalimeter have been required to neutralize the 168.7 grains of neutral carbonate of soda (see Nos. 11, 12), then 75 measures of acid should be poured at once into a glass cylinder accurately divided into 100 parts, the remaining 25 divisions should be filled up with water, and the whole being stirred up, 100 parts of the liquor will now contain as much real acid as 75 parts contained before.

15. This test-acid may now serve for the alkalimetical assay of soda, and be labelled as *test sulphuric acid for soda*.

Each degree or division of the alkalimeter represents one grain of pure soda.

16. The stock of test-acid must be kept in well-stoppered flasks, for the reasons given before. See No.10.

PREPARATION OF THE TEST-ACID FOR BOTH POTASH,
SODA, AND OTHER BASES.

17. Instead of preparing two kinds of test-acids of different saturating powers, the one for potash and the other for soda, one kind only may be adjusted for all alkalies; that is to say, the test sulphuric acid may be at once prepared of such a strength that 1000 grains-measure will exactly saturate one equivalent of every base; such a test, which was first proposed, I believe, by Dr. Ure, is exceedingly convenient.

18. The sulphuric acid used for the purpose should have a specific gravity of 1.032, and should exactly neutralize 54 grains of pure anhydrous neutral carbonate of soda, that quantity containing exactly one equivalent or 32 grains of pure soda.

19. Dissolve therefore 54 grains of pure anhydrous neutral carbonate of soda (obtained as indicated at No. 6) in about 1 ounce of water, and prepare in the mean time the test sulphuric acid by mixing one part by measure of concentrated sulphuric acid with about 11 or 12 parts by measure of water, and stir the whole well. When the mixture has become quite cold, fill the alkalimeter with the cold diluted acid up to the point marked 0°, taking the under line of the liquid as the true level, and whilst stirring briskly the aqueous solution of the 54 grains of neutral carbonate of soda above alluded to, pour the acid carefully, and drop by drop, from the alkalimeter in the vortex produced by stirring, until, by testing the liquor alternately with reddened and then with blue litmus paper (see No. 6), the exact neutralization is obtained.

20. If the whole of the 100 divisions (1000 grains-measure)

sure) have been required to neutralize exactly the 54 grains of pure anhydrous neutral carbonate of soda, it is a proof that the acid is of the right strength; but if this is not the case it must be adjusted as described before (see No. 8), that is to say:—

21. Let us suppose, for example, that only 50 measures of the acid in the alkalimeter have been required to saturate or neutralize the 54 grains of carbonate of soda (see Nos. 18, 19); then 50 measures should be poured at once into a glass cylinder, accurately divided into 100 parts, the remaining 50 divisions should be filled up with water, and the whole being well stirred, 100 parts of the acid liquor will now contain as much real acid as was contained before in the 50 parts.

22. The acid may now be labelled simply *test-sulphuric acid*, it contains 1 equivalent or 40 grains of real sulphuric acid, and 1000 grains-measure of such an acid will therefore neutralize—

32	grains of soda,
48	—— of potash,
17	—— of ammonia,
28	—— of lime,

and so forth; that is to say, it will neutralize one equivalent of each base.

23. The stock of test-acid must be kept in well-stoppered flasks, in order to prevent concentration by evaporation, as said before, (see No. 10.) By keeping in the flask containing it, a glass bead exactly adjusted to the specific gravity of 1.032, at 60° temperature, the operator may always see, at a glance, whether the acid requires re-adjusting.

PREPARATION OF THE TEST-ACID FOR THE POTASH AND SODA ALKALIMETER.

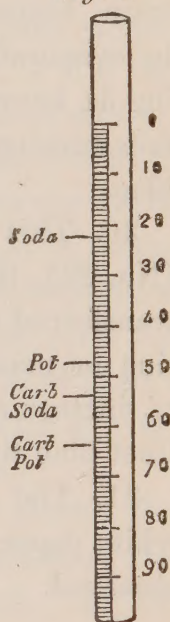
24. In the same manner as a test-acid may be prepared, so adjusted that the same quantity will neutralize various

kinds of bases, an alkalimeter may be, and is often, constructed in such a manner, that it may serve for the assay of both potash and soda, and their respective carbonates.

25. The alkalimeter in question should be, in shape, similar to that of Gay Lussac's, see fig. 1, or to that described fig. 2; but it generally consists of a tube closed at one end, about three-fourths of an inch internal diameter, and $9\frac{1}{2}$ inches in length. It is graduated into 100 equal parts, and every division is numbered from above downwards, see fig. 4. Against some of these divisions the words soda, potash, carbonate of soda, carbonate of potash, are written.

The test-acid for this alkalimeter, fig. 4, should have a specific gravity of 1.1268, and an acid of that strength is prepared by mixing one part by weight of sulphuric acid of specific gravity 1.82 with 4 parts of water, and allowing the mixture to cool. In the mean time 100 grains of pure anhydrous carbonate of soda (obtained as indicated at No. 6) should be dissolved in water, and the test-sulphuric acid of specific gravity 1.1268, prepared as above-said, having become quite cold, is poured into the alkalimeter, up to the point marked carbonate of soda, the remaining divisions are filled up with water, and the whole should be well mixed by shaking.

Fig. 4.



27. If the whole of the 100 divisions of the sulphuric acid, adjusted as just said, being poured carefully into the solution of the 100 grains of the neutral carbonate of soda (see No. 26), neutralize them exactly, which is ascertained by testing the solution with reddened and with blue litmus paper (see No. 6), it is a sign that the test-acid is as it should be. In the contrary case it must be finally adjusted exactly as we directed, Nos. 8, 14, 21, and which needs not be repeated.

ASSAY OF POTASH.

28. From an average sample of the potash to be examined and previously pulverized, take 1000 grains in weight, and dissolve them in a capsule in about 8 ounces of hot water, filter in order to separate the insoluble from the soluble parts, and wash the insoluble residuum which remains on the filter, until the liquor filtered from the 1000 grains operated upon is brought to form 10,000 grains-measure. (See observations 37 to 39.)

29. If the water used for washing the insoluble portions on the filter, and which must be added until it ceases to pass with an alkaline reaction, has increased the bulk of the filtrate beyond 10,000 grains-measure, it must be reduced by evaporation to that quantity. The water used for washing is known to have no longer an alkaline reaction when it fails turning turmeric paper brown, or reddened litmus paper blue.

30. This being done, 1000 grains-measure of the filtrate (No. 29), that is, one tenth part of the whole solution, are transferred to the glass-beaker or vessel in which the saturation or neutralization is to be effected, and a small quantity of tincture of litmus is added so as to impart a slight but distinct blue tinge to the alkaline solution.

31. The glass-beaker should be placed upon a sheet of white paper, in order that the change of colour may be better observed.

Assay of potash with the test sulphuric acid for potash,
(see Nos. 5 to 10.)

32. The alkalimeter described fig. 1, or that of fig. 2, is now to be filled up to 0° (taking the under line of the liquid as the true level), with the *test sulphuric acid for potash*, and the acid is gradually and carefully poured therefrom in the 1000 grains-measure of the potash-solution contained in the glass-beaker or vessel (No. 30), to which a circular motion should

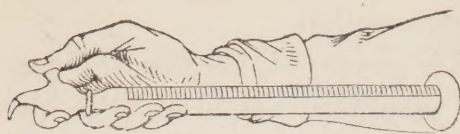
be given whilst pouring the acid, or which should be briskly stirred in order to ensure complete action.

33. At first no effervescence is produced, because the carbonic acid expelled, instead of escaping, combines with the portion of the carbonate as yet undecomposed, which it converts into bicarbonate of potash, but as soon as more than half the quantity of the potash is saturated, the liquor begins to effervesce, and the blue colour of the solution (No. 30) is changed into one of a purple or bluish-red hue, which is caused by the action of the carbonic acid on the litmus. More acid should then be added from the alkalimeter, carefully stirring the liquor all the while, and so on with increased caution as the point of neutralization is approached, which is known by drawing the glass rod used for stirring across a slip of litmus paper. If the paper remains blue, or if a red or reddish streak is thereby produced which disappears on drying the paper, it is due only to the action of the carbonic acid, it is a proof that the neutralization is not yet complete, and more acid must be added, one drop only at a time, stirring after each addition, until at last the liquor assumes a distinct red or pink colour. The streaks now made upon the litmus paper being produced by the extremely slight excess of sulphuric acid, will remain permanently red after drying, and this indicates that the experiment is at an end.

34. This point being attained, the operator allows the sides of the alkalimeter to drain, and he then reads off the number of divisions which have been employed. If for example 50 divisions have been used, then the potash examined contained 50 per cent. of real alkali. (See the observations No. 42 and following.)

35. When the alkalimeter, described fig. 2, is employed, the test-acid may, at the beginning of the experiment, be poured from the larger opening E, but towards the end, that is, when the neutralizing point is approaching, the acid should be carefully poured from the point D, in single drops, until the saturating point is attained, as we just said. If the

Fig. 5.



operator wishes to pour only one drop, he should close the larger opening E of the bulb with the thumb, as in the above figure, and then fill the bulb with the test-acid by inclining the alkalimeter; putting now the alkalimeter in an upright position, a certain quantity of acid will be retained in the capillary point D; and if the thumb be then pressed somewhat forcibly against the opening E, the acid contained in that capillary point will be forced out, and form one small drop, which will then fall into the alkaline solution. If, on the contrary, the saturation is complete, the bulb stopper may be removed, and the drop of acid engaged in the capillary point may either be pressed out as just said, or blown back into the alkalimeter; or else, without removing the bulb stopper, the operator, by applying his lips to the large opening E, may suck the acid engaged in the capillary point back into the alkalimeter.

Assay of potash with the test sulphuric acid for potash, soda, and other bases. (See Nos. 17 to 23.)

36. If instead of the special test-acid for potash above described, the operator prefers that prepared of such strength that one hundred divisions of the alkalimeter (1000 grains-measure) contain exactly one equivalent of real acid, and can consequently saturate one equivalent of each alkali or base, and which test sulphuric acid has a specific gravity of 1.032, as described Nos. 17 to 23, the operator proceeds exactly as was indicated from Nos. 28 to 31, and the alkalimeter being filled with that test-acid of sp. gr. 1.032 up to 0°; it (the acid) should be poured carefully into the aqueous solution of the alkali, tinged blue with litmus, until the exact neutralization is attained, precisely in the same manner as from Nos. 23 to 33.

37. The neutralizing point being hit, let us suppose that the whole of the contents of the alkalimeter have been

employed, and that the aqueous alkaline solution tinged blue with litmus, is not yet saturated, and that after having refilled the alkalimeter again, 4 divisions more, *altogether* 104 divisions, have been required to neutralize the alkali in the aqueous solution; then, since 100 divisions (1000 grains-measure) of the test-acid now employed, saturate exactly one equivalent, that is 48 of potash, the question is now, what quantity of potash will have been saturated by the 104 divisions employed? The answer is found, by a simple rule of proportion, to be nearly 50.

$$100 : 48 :: 125 : x = 49.92.$$

The sample of potash examined contained therefore nearly 50 per cent. of pure potash. See observations, No. 41.

Assay of potash with the potash and soda alkalimeter.

(See Nos. 24 to 27.)

38. If instead of the special test-sulphuric acid for potash (Nos. 5 to 10), or of the test-sulphuric acid for potash, soda, and other bases (Nos. 17 to 23), the operator uses the potash and soda alkalimeter (24 to 27), the method to be followed is exactly that described from 28 to 31. Some of the sulphuric acid of specific gravity 1.268, (see 26,) is to be poured into the alkalimeter until it reaches the point marked *potash*, (taking the under line of the liquid as the true level,) and the remaining divisions of the alkalimeter are carefully filled with water. The operator then closes the aperture of the tube with the thumb of the left hand, and the whole is violently shaken until perfectly mixed.

39. The acid must now be carefully poured from the alkalimeter into the alkaline solution of the potash under examination, until neutralization is attained, precisely as described from Nos. 32 to 33.

40. The neutralizing point being hit, the operator allows the sides of the alkalimeter to drain, and he then reads off the number of divisions employed, which, if that number be 50, indicates, of course, that the potash examined contained 50 per cent. of real potash.

41. Had the operator wished to know the quantity of *carbonate of potash*, he should have poured the test-acid in question into the alkalimeter up to the point marked "*carbonate of potash*," filled the remainder with water, and proceeding exactly as just mentioned, and admitting that the sample under examination contains 50 per cent. of real potash, the number of divisions employed would be found to correspond to nearly 73 degrees, 50 grains of real potash being equivalent to nearly 73 grains of pure carbonate of potash.—(See the following observations also.)

OBSERVATIONS.

42. In alkalimetical assays, and considering the rapidity with which the operation may be performed, it is advisable not to rest satisfied with *one* trial, but to repeat the examination twice or thrice, the first trial being intended only as a sort of guide or approximative assay of the degree of saturation, which is more accurately determined by repeating the experiment.

43. Or, if the operator will not take this little extra trouble, he should, at any rate, before he begins to pour the acid, take a little of the filtered alkaline solution out of the glass beaker or vessel, as a *corps de réserve*, with which he completes the saturation.

44. Instead of taking 1000 grains in weight of the potash to be examined, and in order to ensure the complete decomposition of the carbonate of potash, and to produce the distinct pink tinge which indicates that the saturating point is attained, (No. 33,) the sulphuric acid must be added in slight excess, the estimation therefore is always a little too high; consequently, in order to render the alkalimetical analysis strictly accurate, a correction is absolutely required, that is to say, the excess of sulphuric acid must be deducted. Let us suppose, for example, that in order to obtain a permanently red streak upon the litmus paper, the operator has added two drops of acid more than are required to render

the solution perfectly neutral ; he must ascertain how many drops are contained in one division of the alkalimeter. Suppose, which is generally the case, that each division contains 10 drops, then the operator subtracts the 2 drops of sulphuric acid in excess from the number indicated by the alkalimeter ; that is to say, he must subtract $\frac{2}{10}$ from that number. In the example given before, the per cent. of the potash examined instead of being 50, would be $50 - 0.2 = 49.8$ per cent. of real potash.

ASSAY OF SODA-ASH.

45. The alkalimetical estimation of soda is performed exactly in the same manner as that of potash. That is to say, from an average sample of the soda to be examined, take 1000 grains in weight, and boil it for five or six minutes, in about 8 ounces of water, filter from the insoluble portion, and wash the residuum on the filter with boiling water, until it no longer drops from the filter with an alkaline reaction (29), and the bulk of the solution has increased to 10,000 grains-measure. If the solution has been increased beyond that, by the water required for washing the insoluble residuum on the filter, it should be reduced by evaporation to that bulk.

46. This being done, 1000 grains-measure—that is, one-tenth part of the aqueous solution of the soda-ash above mentioned, (45,) is transferred to the glass beaker or vessel in which the saturation is intended to take place, it is tinged distinctly blue with tincture of litmus (30), and the operation is performed in the same manner and with the same precautions as for potash ; the glass beaker containing the blue alkaline solution being placed upon a sheet of white paper, the better to observe the change of colour which takes place when the saturating point is approaching.

Assay of soda with the test-sulphuric acid for soda.

47. Having put into a glass beaker the 1000 grains-measure of the aqueous solution of soda-ash to be examined,

(44, 45,) the alkalimeter described fig. 1, or that in fig. 2, is now to be filled up to the point marked 0° , (taking the under line of the liquid as the true level,) with the *test-sulphuric for soda*, described before, (see 11 to 16,) and poured therefrom with great care, and, at the same time, stirring briskly the liquid in the beaker, exactly as was described for the saturation of potash; the carbonic acid expelled by the acid reacting upon the as yet undecomposed portion of the carbonate of soda in the solution, converts it into bicarbonate of soda, so that at first no effervescence is produced; but as soon as more than half the quantity of the soda in the solution is saturated, a brisk effervescence takes place. The operator may therefore pour at once a pretty large quantity of acid from the alkalimeter without fear; it is only when the effervescence begins that he should proceed with increased care as the point of neutralization is approached. The mode of operating is precisely like for potash, (33,) the assay is known to be terminated when the streaks made upon the strips of blue litmus paper with the stirring rod leave a distinct and permanent pink colour.

48. If after saturation and allowing the sides of the alkalimeter to drain, the number of divisions employed is for example 52, then the sample operated upon contained 52 per cent. of real soda. (See the observations 42 and following, also the observation No. 54.)

Assay of soda with the test sulphuric acid for potash, soda, and other bases. (No. 17 to 23.)

49. If, instead of the special test-acid for soda just alluded to, the operator employs that which has a specific gravity of 1.032, and 100 divisions (1000 grains-measure) of which saturate one equivalent of each base, the method is absolutely similar to that just described, 47, 48;) the alkalimeter is then filled up to 0° with this test-acid, from which it is carefully poured into the alkaline solution, until the exact neutralizing point is hit.

50. But the equivalent of soda being 32, and 100 divisions of the test-sulphuric acid now employed being capable of saturating only that quantity of soda, it is clear that with the soda-ash taken as an example in the preceding case, and containing 52 per cent. of real soda, the operator will have to refill the alkalimeter, and that a certain number of divisions of this second filling will be employed to perfect the saturation. In this instance the operator will find that $60\frac{1}{2}$ divisions more, altogether one hundred and sixty divisions and a half, have been required,

$$100 : 32 :: 160.5 : x = 52.$$

The sample of soda examined contained therefore 52 per cent. of real soda. (See observations 42 and following, and also 54.)

Assay of soda with the potash and soda alkalimeter.

(No. 24—27.)

51. If instead of the special test-sulphuric acid for soda (11 to 16), or of the test-sulphuric acid for potash, soda, and the other bases (17 to 23), the operator uses the potash and soda alkalimeter (24—27), the method is always that described from 44 and 45. That is to say, the aqueous solution of soda is poured into the glass beaker as there described, and then some of the sulphuric acid of specific gravity 1.268 (see No. 26) is poured into the alkalimeter until it reaches the point marked “soda, (taking the under line of the liquid as the true level)” and the remaining divisions of the alkalimeter are carefully filled up with water. The aperture of the tube should then be thoroughly closed with the thumb of the left hand, and the whole is violently shaken until perfectly mixed, taking great care of course not to squirt any of the acid out of the tube, which evidently would be a cause of error proportionate to the quantity of liquor which would have thus been lost.

52. The acid should next be carefully poured from the alkalimeter into the alkaline solution of the soda under examination into the glass beaker, until neutralization is attained

with all the precautions described before, (46,) stirring briskly all the while, or after each addition of acid. The neutralizing point being attained, the operator allows the sides of the alkalimeter to drain, and then reads off the number of divisions employed, which, if that number be 52, indicates of course that the soda-ash assayed contained 52 per cent. of real soda.

53. If the operator wishes to know what quantity per cent. of carbonate of soda these 52 per cent. of caustic soda correspond to, or, which is the same thing, if he wishes to know what quantity of *carbonate of soda* is contained in 100 parts in weight of the soda under examination, he should pour the test-acid in question (specific gravity 1.268) into the alkalimeter up to the point marked *carbonate of soda*, fill the remaining divisions with water, shake the whole well, and proceed exactly as just described. Admitting that it is the same sample, that is to say, that it contains exactly 52 per cent. of real soda, it will be found that the number of divisions employed are now $87\frac{3}{4}$, for 52 of caustic soda correspond exactly to 87.75 of carbonate of soda. (See the following observation, also No. 52.)

OBSERVATION.

54. If the soda-ash is very poor, instead of operating upon 1000 grains-measure, or one-tenth part of the whole solution (45, 46), it is advisable to take three or four thousand grains-measure, and to divide by three or four the number of divisions of the test-acid employed to saturate them. Suppose, for example, that having taken 4000 grains-measure of the alkaline solution, the number of divisions of the test-acid which have been employed is 52, this, divided by four, will give 13 as the per centage of real soda contained in the sample.

55. The soda-ash of commerce contains generally insoluble substances which are removed by filtering, as we said, and a

greater or less quantity of chloride of sodium (common salt) and of sulphate of soda, which, however, do not interfere with the accuracy of the result ; but when sulphurets, sulphites, or hyposulphites, are present, these substances, neutralizing a certain quantity of the test-acid, would render the estimation seriously inaccurate ; wherefore it is absolutely necessary, in such cases to transform these substances into sulphates by calcining a given quantity of the sample with five or six per cent. of chlorate of potash, as recommended by Gay Lussac and Welter. The operator therefore should intimately mix 500 or 600 grains of pulverized chlorate of potash with 100 grains of the pulverized sample, and fuse the mixture in a platinum crucible, for which purpose my blowpipe gas-furnace will, I think, be found exceedingly convenient. The fused mass should then be dissolved in boiling water, filtered, washed, and in every respect assayed as was described before, with one or the other of the test-acids mentioned.

56. Yet, if the soda-ash contains any hyposulphite, it should not be calcined with chlorate of potash, because under the influence of this substance, one equivalent of hyposulphite becomes transformed, *not into one equivalent only of sulphate*, but, reacting upon one equivalent of carbonate of soda, expels its carbonic acid, and forms with the soda of the decomposed carbonate, a *second equivalent* of sulphate of soda, each equivalent of hyposulphite becoming thus converted into two equivalents of sulphate, and therefore creating an error proportionate to the quantity of the hyposulphite present, each equivalent of which would thus destroy one equivalent of real and available alkali, and thus render the estimation of the sample inaccurate *pro tanto*.

57. It is therefore preferable, according to Messrs. Fresenius and Will, to add to the alkaline solution of the sample a small quantity of yellow chromate of potash, the chromic acid of which transforms the sulphites, hyposulphites, and

sulphurets, into sulphates and water, with separation of sulphur.

Detection of sulphuret of sodium, sulphite, or hyposulphite of soda, in soda-ash.

58. Whether the sample to be analyzed contains any sulphuret of sodium, sulphite, or hyposulphite of soda, is easily ascertained as follows :—

59. If, on pouring sulphuric acid upon a portion of the soda-ash under examination, an odour of rotten eggs (sulphuretted hydrogen) is evolved ; or if a portion of the soda-ash, being dissolved in water, and then filtered, produces a black precipitate (sulphuret of lead), when solution of acetate of lead is poured into it, then the sample contains sulphuret of sodium.

60. And if to dilute sulphuric acid, tinged reddish yellow by some bichromate of potash, a certain portion of the soda-ash under examination being added, but not in sufficient quantity to saturate the acid completely, imparts a green tinge to the acid liquor, it is a proof that the sample contains either sulphite or hyposulphite of soda, the green tinge being due to the transformation of the chromic acid into oxyde of chromium.

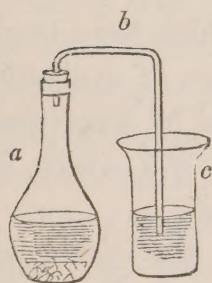
61. If muriatic acid, being poured into a *clear* solution of the soda-ash and left at rest, becomes turbid after some time, and evolves an odour of sulphurous acid (the odour of burning brimstone), the turbidness is produced by a separation of sulphur, and it indicates the presence of hyposulphate of soda.

Estimation of the caustic soda contained in soda-ash.

62. The soda-ash of commerce frequently contains some caustic soda, the proportion of which it is sometimes important to determine. This may be done, according to M. Bar-

reswill, by adding an excess of solution of chloride of barium to the aqueous solution of the soda-ash under examination ; the carbonate of soda is thereby converted into carbonate of baryta, whilst the caustic soda, re-acting upon the chloride of barium, a quantity of free baryta is thus produced, proportionate to that of the caustic soda in the soda-ash. After this addition of chloride of barium the liquor is filtered, in order to separate the precipitated carbonate of baryta produced, and which remains on the filter, on which it should be washed with pure water. A few lumps of chalk

Fig. 6.



are then put into a Florence flask *a*, and some dilute muriatic acid being poured upon it, an effervescence due to a disengagement of carbonic acid is produced ; the flask is then closed with a good cork, provided with a bent tube *b*, reaching to the bottom of the vessel *c*, and the stream of carbonic acid produced is then passed through the liquor *c*, filtered from the carbonate of baryta above-

mentioned. The stream of carbonic acid produces a precipitate of carbonate of baryta, which should be also collected on a separate filter, washed, dried, and weighed. Each grain of this second precipitate of carbonate of baryta corresponds to 0.32 of caustic soda.

63. As the soda-ash of commerce almost invariably contains earthy carbonates, the sample operated upon should always be dissolved in boiling water and filtered, in order to separate the carbonate of lime which otherwise would in all circumstances saturate a proportionate quantity of the test-acid and render the analysis worthless.

Estimation of the quantity of water contained in potash and in soda-ash.

64. The quantity of water contained in either potash or soda-ash is ascertained by heating a weighed quantity of the

sample to redness in a covered platinum crucible. The loss, after ignition, indicates the proportion of water. If any caustic alkali is present, one equivalent, $= 9$ of water, is retained, which cannot be thus expelled, but which may be estimated by calculation, after the proportion of the caustic alkali has been determined as shown before, each 32 grains of caustic alkali containing 9 grains of water.

DRS. FRESENIUS AND WILL'S ALKALIMETRICAL PROCESS.

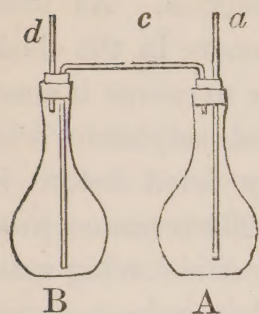
65. Besides the alkalimetical processes which have been explained in the preceding pages, the proportion of available alkali contained in a sample may be estimated by ascertaining the amount of carbonic acid contained therein, and which is disengaged on neutralizing the carbonated alkali.

66. This method, however, of estimating the value of alkalies by the weight of the carbonic acid gas liberated, and which is always proportionate to the quantity of real alkali in the carbonate operated upon, has been long known; Dr. Ure, in the "Annals of Philosophy," for October, 1817, and more lately in his pamphlet "Chemistry Simplified," described several instruments for analyzing earthy and alkaline carbonates by the quantity of carbonic acid disengaged from them when treated by an acid. The ingenious little apparatus employed by Drs. Fresenius and Will for the the same purpose, gives also accurate results; but it should be observed, that when the potash or soda-ash of commerce contains any caustic alkali, or bicarbonate of alkali, or any earthy or other carbonates, for example, carbonate of lime, which is frequently the case, this process is not applicable, unless the caustic alkali or its carbonate be previously converted into the neutral carbonate; the earthy carbonate, which may be present likewise, must be removed beforehand.

67. The apparatus of Drs. Fresenius and Will consists of

two flasks, A, B. The first must have a capacity of from two to two ounces and a half ; the second, or flask B, should be of a smaller size, and hold from one ounce and a half to two ounces. Both flasks must be provided with perfectly sound corks, each perforated with two holes through which the tubes *a*, *c*, *d*, are passing. The lower extremity of the tube *a* must be so adjusted as to reach nearly to the bottom of the flask A.

Fig. 7.



and its upper extremity is closed at *b* by means of a small pellet of wax ; *c* is a tube bent twice at right angles, one end of which merely protrudes through the cork into the flask A, but the other end reaches nearly to the bottom of the flask B. The tube *d* of the flask B merely protrudes through the cork into the flask.

The apparatus being disposed as just said, a certain quantity, 100 grains for example, of the potash or soda-ash under examination (and which may have been previously dried as described No. 64), is weighed and introduced into the flask A ; water is next poured into this flask to about one third of its capacity ; concentrated sulphuric acid is now poured into the flask B, and the corks are firmly put on the flasks which thus become connected so as to form a twin-apparatus, which is then put on a delicate balance and accurately weighed.

68. The weight of the apparatus being noted down, the operator should now apply his lips to the extremity of the tube *d*, and suck out a few air bubbles, which rarefies the air in the flask A, and consequently causes the sulphuric acid of the flask B to ascend a certain height (after the suction) into the tube *c* ; and if after a short time the column of sulphuric acid maintains its height in the tube *c*, it is a proof that the apparatus is air-tight, and therefore as it should be. This being ascertained, suction is again applied to the extremity of the tube *d*, so that a portion of the sulphuric acid

of the flask B ascends into the tube *c*, and presently falls into the flask A, the quantity which thus flows over being proportionate to the vacuum produced by suction. As soon as the acid comes in contact with the carbonate in the flask A, carbonic acid is disengaged, and in order to escape it must pass by the tube *c*, through the concentrated sulphuric acid of the flask B, by which it is completely dried before it finally escapes through the tube *d*. The effervescence produced by the disengagement of the carbonic acid having subsided, suction is again applied to the tube *d*, in order to cause a fresh quantity of sulphuric acid to flow over into the flask as before, and so on, until the carbonate being completely decomposed, carbonic acid ceases to be evolved. When this point is obtained, a powerful suction is applied to the tube *d*, in order to cause a tolerably large quantity of acid to flow into the flask A, which thus becomes very hot, from the combination of the concentrated acid with the water, so that the carbonic acid is thoroughly disengaged from the solution.

69. When all evolution of carbonic acid gas has ceased, the little stopper of wax is carefully removed from the tube C, and suction applied for some time, in order to remove the carbonic acid contained in the flasks and replace it by atmospheric air. When the apparatus has become quite cold it is weighed again, the difference of weight between this second weighing and the first, that is to say, the *loss*, indicates of course the quantity of carbonic acid which was contained in the carbonate and which has escaped, from which, of course, the quantity of the carbonated alkali operated upon may be calculated. Suppose in effect that the loss is $19\frac{1}{2}$ grains, taking the equivalent of soda=32, and that of carbonic acid=22, (carbonate of soda=54,) it is clear that if 22 of carbonic acid represent 32 of soda or 54 of carbonate of soda, the $19\frac{1}{2}$ grains of carbonic acid which were disengaged represent 48 grains of carbonate of soda, or, in other words, the

100 grains of soda-ash operated upon contained 48 per cent. of carbonate of soda.

$$\begin{array}{ccccccc} \text{CO}_2 & & \text{Na}_2\text{O}, \text{CO}_2 & & \text{CO}_2 & & \text{Na}_2\text{O}, \text{CO}_2 \\ 22 & : & 54 & : : & 19.5 & : & x = 48. \end{array}$$

70. As the soda-ash of commerce always contains earthy carbonates, instead of putting the 100 grains which are to be analyzed directly into the flask A, it is absolutely necessary first to dissolve them in boiling water, to filter the solution, and to wash the precipitate that may be left on the filter with boiling water. The solution and the washings being mixed together, should then be concentrated by evaporation to diminish their bulk to the proper volume for introduction into the flask A, and the process is then carried on as described.

71. If the soda-ash under examination contains any sulphuret of sodium, sulphite or hyposulphite of soda, it must be treated exactly as was described Nos. 58 to 61, previous to beginning the analysis, since otherwise sulphuretted hydrogen and sulphurous acid would be disengaged along with the carbonic acid, which would apparently augment the proportion of the latter and render the result quite erroneous.

72. If the soda-ash contains any caustic soda, which is frequently the case, Drs. Fresenius and Will prescribe to weigh off a portion of the sample, and to triturate it in a mortar with about 3 or 4 parts of quartzose sand, and about one third part of carbonate of ammonia. The whole is then put into a small iron capsule, and the mass being moistened with aqueous ammonia is then evaporated to dryness, in order to expel the ammonia and carbonate of ammonia. The mass is then treated by water, filtered, washed, concentrated to the proper bulk by evaporation, and then treated as described.

73. The balance used for this mode of analysis should be capable of indicating small weights when heavily laden.

ALQUIFOUX.

ARQUIFOUS. POTTERS' ORE. GALENA. SULPHURET OF LEAD.

1. Alquifoux is a combination of sulphur and of lead (sulphuret of lead), which is used by potters to give a green varnish or enamel to pottery, on which account it is sometimes called potters' ore; it may be analyzed in the same way as galena.—(See *Lead Ores*.)

ALUM.

1. The substance known as common alum is a double sulphate of alumina and of potash ($\text{KO}, \text{SO}_3 + \text{Al}_2 \text{O}_3, 3 \text{SO}_3$), but all alums do not necessarily contain alumina (clay) or potash. The word alum means, in chemical language, a combination of sulphate of potash with another sulphate, or a combination in which sulphate of potash is replaced by a sulphate of a base having one equivalent of oxygen; for example:—

Sulphate of alumina and of potash (common alum)	}	$\text{KO}, \text{SO}_3 + \text{Al}_2 \text{O}_3, 3 \text{SO}_3$
Sulphate of alumina and of soda (soda alum)	}	$\text{NaO}, \text{SO}_3 + \text{Al}_2 \text{O}_3, 3 \text{SO}_3$
Sulphate of iron and of potash (iron alum, or plumose alum) . }		$\text{KO}, \text{SO}_3 + \text{Fe}_2 \text{O}_3, 3 \text{SO}_3$
Sulphate of potash and of chrome (chrome alum)	}	$\text{KO}, \text{SO}_3 + \text{Cr}_2 \text{O}_3, 3 \text{SO}_3$
Sulphate of alumina and of ammonia (ammonia alum)	}	$\text{NH}_4\text{O}, \text{SO}_3 + \text{Al}_2 \text{O}_3 + 3 \text{SO}_3$
Sulphate of manganese and of chrome		$\text{MnO}, \text{SO}_3 + \text{Cr}_2 \text{O}_3 + 3 \text{SO}_3$

2. All alums crystallize in cubes or in octahedrons, and they all contain the same number of equivalents of water; namely, 24 equivalents. The ammonia-alums, however, form an exception; they contain, according to Pelouze, 25 equivalents of water.

3. The most important of all alums, in a technical point of

view, is the potash-alum (common alum), or double sulphate of alumina and potash (KO, SO_3); ($\text{Al}_2 \text{O}_3, 3 \text{SO}_3$) 24HO , very large quantities of which are manufactured, both in this country and abroad, for various processes in the arts. It is extensively used for dyeing, as a mordant, in the manufacture of paper, of candles, of crayons, and a variety of other purposes.

4. The *Roman alum* has generally a reddish colour, due to the presence of peroxyde of iron, which, however, being insoluble, does not interfere with its use in dyeing.

5. Most of the alum used in England is extracted from aluminous schistus, containing sulphuret of iron, and some bituminous matter. By exposure to the air the sulphuret of iron becomes converted into sulphate of iron, and into sulphuric acid, the consequence of which is, that the alum prepared from such materials, retains traces of sulphate of iron, which render it unfit for certain dyeing operations. Even so small a trace as 0.005 interfere with the brightness of several colours.

6. The presence of iron is detected by dissolving a portion of the alum, and testing the solution with tincture of galls, which will then impart a black tinge to the liquor. Iron may be detected also by adding a large excess of caustic potash to the solution, and boiling the whole, the peroxyde of iron will then fall down in the form of an insoluble reddish-brown precipitate.

7. It should be observed, that at first, the addition of potash to the solution produces a bulky precipitate, because both the alumina and the iron are thrown down; but if a sufficient quantity of solution of caustic potash is added, and the whole be boiled, the alumina is redissolved, and the insoluble portion ultimately consists of peroxyde of iron only, which should be collected and thoroughly washed on a filter; after which, if the proportion obtained admits of it, it may be ignited and weighed, if need be, though for greater accuracy it is best to redissolve in muriatic acid the peroxyde of iron.

collected on the filter, and to reprecipitate it by adding ammonia, which will then throw down the peroxyde of iron only.

8. Lastly; the presence of iron may be detected in the solution, by testing with solution of ferrocyanuret of potassium (prussiate of potash), which, in that case, will strike a blue precipitate (Prussian blue.)

9. Pure alum is completely soluble in water but in different proportions according to the temperature.

According to Poggiale,

100 parts of water at	0° Fahr.	dissolve	3.29
"	"	50	" 9.52
"	"	86	" 22.00
"	"	140	" 31.00
"	"	158	" 90.00
"	"	212	" 357.00

10. A concentrated solution of alum in boiling water deposits octahedral crystals in cooling, and if these crystals are then redissolved in water at from 104° to 120° Fahr. adding potash until the precipitate at first produced by this re-agent is no longer redissolved, by filtering and crystallizing the filtered liquor at a gentle heat, alum is obtained in cubes free from iron and perfectly pure.

AMALGAMATED SILVER.—See *German Silver*.

A M B E R.

SUCCIN.

1. It is now generally admitted that amber is a fossil substance of vegetable origin, formerly in the state of a balsam or resin, dissolved in a natural volatile oil, and similar to the resins which exude from several of our trees.

2. Amber, as found in nature, is in translucent lumps, sometimes colourless, but more generally of a light yellow, and occasionally of a dark brown or of a milk-white colour, and opaque. It is harder than all other resins, and is capable of receiving a fine polish, on which account it is often employed for ornamental purposes.

3. When amber is in small fragments, which is most generally the case, especially with that which is employed for making varnish, and for preparing succinic acid, it is often adulterated or mixed with small pieces of resin copal, or anime. This admixture, however, may be recognized by a careful examination of the article, because the pieces of resin copal, and of resin anime have a different appearance and fracture. The suspected pieces should be selected out, and, if they be thrown upon red-hot iron, it will be observed that they will not emit the peculiar odour of amber, whilst, on the other hand, the resin will fuse and fall into drops, which is not the case with amber.

AMBER-GREASE.

AMBERGRIS. GREY AMBER.

1. Ambergris is a solid, opaque, uneven, fatty, and inflammable mass, of a light grey colour, of a darker hue externally than internally, variegated with yellow or reddish streaks.

2. Ambergris softens like wax by the heat of the hand, and emits a slight but agreeable odour when heated. Ambergris has scarcely any other use than in perfumery.

3. It is now generally admitted that this substance is a morbid concretion, analagous to the biliary calculi, formed in the stomach or intestines of the spermaceti-whale. Its composition is very simple ; it consists almost entirely of a non-

saponifiable grease analogous to cholesterine, and mixed with a portion of the excrements of the animal.

4. Great care is requisite in purchasing this substance, because it is easily imitated by a mixture of several gums and other drugs. The criterion of genuine ambergris is, that it may be easily perforated by a heated needle, and on withdrawing it, not only should the odour of ambergris be immediately evolved, but the needle should come out clean without anything whatever adhering to it.

5. Ambergris should be chosen in large pieces, externally of a uniform grey colour, internally of a lighter shade of grey with little black specks, and of an agreeable odour.

6. The specific gravity of ambergrease is from 0.908 to 0.92. The analysis of ambergris gives the following results :

Peculiar grease (ambreine)	. . .	85.
Balsamic matter, of a sweet acidulous taste, soluble in alcohol and in water, probably containing benzoic acid	. . .	2.5
Matter soluble in water, benzoic acid, and chloride of sodium	. . .	1.5
Loss	. . .	11.0
		100.0

A M M O N I A.

SPIRITS OF HARTSHORN. VOLATILE ALKALI. LIQUOR AMMONIÆ.

1. Ammonia is a colourless gas, permanently elastic, at ordinary temperatures, very soluble in water. The usual state in which it is employed, is in aqueous solution, which, when saturated, has a specific gravity of 0.875. One of the ways of ascertaining the quantity of real ammonia contained in the aqueous solution is by taking its specific gravity, either by means of the hydrometer or of the specific gravity bottle.

Reference to the following tables will show the quantity of ammonia in solutions of different specific gravities :—

TABLE BY SIR H. DAVY.

100 parts of Sp. Gr.		of Ammonia.	100 parts of Sp. Gr.		of Ammonia.
0.8750	contain	32.50	0.9435	contain	14.53
0.8875	„	29.25	0.9476	„	13.46
0.9000	„	26.00	0.9513	„	12.40
0.9050	„	25.37	0.9545	„	11.56
0.9166	„	22.07	0.9573	„	10.82
0.9255	„	19.54	0.9597	„	10.17
0.9326	„	17.52	0.9619	„	9.60
0.9385	„	15.88	0.9692	„	9.50

But the quantity of ammonia stated in the above table is probably too high by about 1 per cent.

The following table by Dr. Ure, indicates the quantity of ammonia in 100 parts, by weight, of its aqueous solutions of different successive densities :

Water Sp. Gr. 0.900	Ammonia. in 100.	Water in 100.	Sp. Gr. by Experience.
100	26.500	73.500	0.9000
95	25.175	74.825	0.9045
90	23.850	76.150	0.9090
85	22.525	77.475	0.9133
80	21.200	78.800	0.9177
75	19.875	80.125	0.9227
70	18.550	81.450	0.9275
65	17.225	82.775	0.9320
60	15.900	84.100	0.9363
55	14.575	85.425	0.9410
50	13.250	86.750	0.9455
45	11.925	88.075	0.9510
40	10.600	89.400	0.9564
35	9.275	90.725	0.9614
30	7.950	92.050	0.9662
25	6.625	93.375	0.9716
20	5.300	94.700	0.9768
15	3.975	96.025	0.9828
10	2.650	97.350	0.9887
5	1.325	98.675	0.9945

2. The real quantity of ammonia contained in its solutions can also be ascertained by its saturating power, in the same manner as we described in the article on alkalimetry, thus:—

3. Take for example 1000 grains-measure of the test-sulphuric acid of sp. gr. 1.032 mentioned page 22, and drop it from the acidimeter into any given weight or measure of the liquor of ammonia under examination, until perfect neutralization is obtained, exactly as we described for alkalimetical trials. As 100 divisions (1000 grains-measure of such an acid saturate exactly 17 grains in weight of ammonia, it is quite evident that the quantity of real ammonia contained in the given weight or measure of liquor of ammonia operated upon, can thus be immediately ascertained.

4. Pure solution of ammonia should be as limpid as water, if it have the slightest brownish hue it is a sign of the presence of organic substances. The solution of pure ammonia should also evaporate entirely when heated, though ordinarily a small carbonaceous residue is left, but it should always be very slight.

5. The presence of the empyreumatic oil by which the aqueous solution of ammonia is often contaminated, may generally be detected, by the odour which may be immediately rendered perceptible by rubbing a little of the ammonia in the palm of the hand, and when evaporated, the film of empyreumatic oil which remains in the hand evolves the characteristic odour.

6. If the proportion of empyreumatic oil, or of organic matter, is at all considerable, its presence may also be detected by adding a large excess of concentrated sulphuric acid which should be poured in the ammonia with great caution, and only one drop at a time. The acid, by charring the organic matter, imparts a black hue to the liquor.

7. The liquor ammonia of commerce contains sometimes *sal ammoniac*, *sulphate of ammonia*, *carbonate of ammonia*, *chloride of calcium*, and sometimes also traces of *protoxyde of copper*, or of *peroxyde of tin*, which may interfere with

certain delicate operations, these impurities may be detected as follows:—

8. A certain quantity of the ammonia under examination should be first supersaturated with pure nitric acid, and a portion thereof is then tested by nitrate of silver. If a white precipitate is thereby produced, which immediately disappears on supersaturating it with ammonia, it is chloride of silver, and is, of course, a sign that the ammonia is contaminated by sal ammoniac.

9. If to another portion of the ammonia, supersaturated by pure nitric acid, an addition of solution of nitrate of baryta produces a white precipitate, it is sulphate of baryta; and, consequently, sulphuric acid or a soluble sulphate is present.

10. If the solution of ammonia contains *carbonate of ammonia*, which is always the case when it has been kept for some time in bottles not carefully stoppered, it is detected by pouring into it a solution of chloride of calcium, or of barium, or else lime-water, in which case a turbidness or a precipitate will be produced, owing to the formation of carbonate of lime or of baryta. If chloride of barium is used, it is, of course, necessary to ascertain that sulphuric acid is absent before the operator can conclude that carbonate of ammonia is present.

11. If the ammonia under examination contains any chloride of calcium, the addition of a solution of oxalic acid will render it turbid, or even produce a precipitate if the quantity of lime is at all large. Moreover, if a portion of the liquor of ammonia be evaporated, a residue will then be left. Pure ammonia is not at all affected by oxalic acid.

12. Traces of *oxyde of copper* are at once detected by the blue colour of the ammonia liquor; if, however, the quantity of copper is too small to impart a blue colour to the liquor as just said, its presence may be rendered apparent by adding hydrosulphuret of ammonia which will then produce a black precipitate of sulphuret of copper.

13. Impure ammonia can always be purified by re-distilling

it slowly. It should then be put into a matrass or retort, connected with an ordinary Woolfe's apparatus, consisting of two bottles, the first of which contains a little concentrated solution of ammonia, and the second contains pure water; heat is then carefully applied, the gas, in passing through the concentrated liquor of ammonia, is washed and is condensed in a perfectly pure state by the water of the second bottle, the impurities which might have been mechanically carried with the gas remain in the first bottle. This process although convenient, however, is not economical, for the whole of the ammonia contained in the original liquor cannot be thus extracted.

ANNOTTO.

ANNATTO. ARNOTTO. ROCOU.

1. Annotto is a colouring matter of a pasty consistence, used for dyeing silk and wool, in the preparation of certain varnishes, &c. It is prepared by macerating the pods of the *bixa orellana* in boiling water, allowing the matter to subside, pouring the water off, and drying it in the shade. The colouring matter is sometimes mixed with oil before drying.

2. Annotto is met with in commerce in cakes and in rolls, hence the name of *flag* and of *cake annotto*, by which these two varieties are distinguished.

3. *Cake annotto* comes almost exclusively from Cayenne, it should be of a bright yellow colour, somewhat firm and soft to the touch.

4. *Roll annotto* comes from Brazils, and is hard and dry, brown outside and red within; it is this species which is daily employed in England for imparting colour to cheese, in the proportion, it is said, of about one ounce of annotto for 1 cwt. of curds. This admixture of annatto to cheese is in no way detrimental to health, provided the drug is pure, but unfortunately, as it is very often adulterated with

red lead, or with both red lead and ochre, the use of such annotto is very injurious, and serious accidents have been caused thereby. (See the article on *Cheese*.)

5. The best way of detecting the presence of lead in annotto consists in heating a portion of the suspected annotto upon charcoal in the reducing flame of the blow-pipe, by which means a bead of metallic lead may be immediately obtained.

6. The proportion of ochre, if any be present, can be determined with sufficient accuracy by incinerating a given weight of the sample, washing the residuum with water, drying and weighing.

The composition of annotto is as follows :—

Annatto mixed with colouring matter	28
Coloured extract	20
Gum	26
Woody fibre, mixed with an acid and an aromatic substance	20
	—
	94
	—

ANTIMONIAL GREY COPPER.—See *Copper Ores*.

ANTIMONY (CRUDE).—See *Sulphuret of Antimony*.

ANTIMONY.

1. Antimony, as is well known, is a brittle metal, which is easily oxydized by nitric acid, but not dissolved by it; because all the degrees of oxydization of this metal are insoluble in that acid. The best solvent of antimony is aqua regia, which dissolves it completely with the help of heat; but when it contains much lead, the solution deposits spangles

of chloride of lead in cooling. If the aqua regia solution of antimony be supersaturated with ammonia, the precipitate formed should be completely soluble in hydrosulphuret of ammonia. If a portion of the precipitate remains undissolved (black metallic sulphuret), the operator may conclude that the antimony contained iron, lead, or other foreign metals.

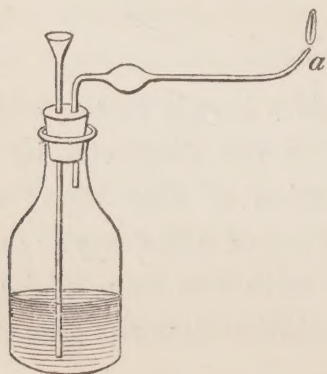
2. The antimony of commerce (regulus of antimony) always contains *sulphur*, *lead*, *iron*, and a small quantity of *arsenic*, the separation of which latter substance is always difficult and troublesome.

3. The real quantity of antimony may be estimated as follows:—

4. A given weight of the antimony, previously pulverized, should be treated by nitric acid, which oxydizes the antimony, and leaves it in an insoluble state, whilst the oxydes of the other metals are taken up by the acid; the sesquioxys of antimony may then be collected on a filter, washed, dried, ignited, and weighed; each grain of sesquioxys of antimony obtained contains 0.84317 of metal.

5. If, however, the antimony contains any *tin*, the process described farther on (see *Alloys of Tin and Antimony*, p. 52) must be resorted to.

6. One of the best methods of detecting the presence of arsenic in antimony consists in pulverizing the suspected metal, mixing it with about its own weight of tartrate of potash, and submitting the mixture to a red heat in a covered crucible for about three hours. When cold, the crucible must be broken, and the metallic button, which is an alloy of



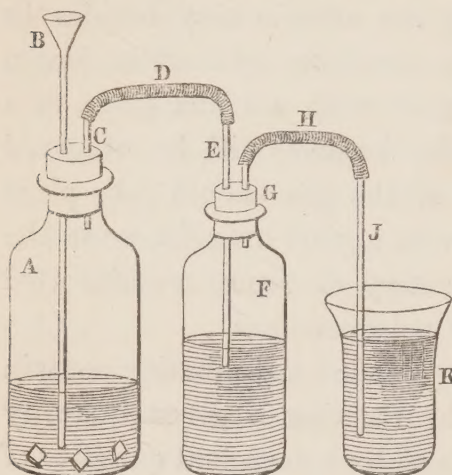
antimony and potassium, is put in a bottle provided with a cork fitting air-tight, perforated with two holes, into one of which a small funnel is fitted; the second hole has a tube with a bulb, and is drawn to a point at *a*. Water is then poured into the bottle through the funnel, when a

disengagement of hydrogen takes place, because the alloy in the bottle decomposes the water. If the antimony contained no arsenic, the hydrogen disengaged is pure; but if the least trace of arsenic is present, the hydrogen escaping at *a* has a characteristic aliaceous odour; the arsenic may besides be rendered visible by inflaming the gas at the point of the drawn tube *a*, and depressing the flame with a china plate, or a piece of mica, spots of metallic arsenic will be observed thereon. The disengagement of the gas should take place under the hood of a chimney with a good draught, or in the open air, but not in the laboratory or room, arseniuretted hydrogen being an exceedingly poisonous gas.

7. The *lead*, if the antimony under examination contain any, may be easily detected by treating a given quantity of the metal previously pulverized, by a sufficient quantity of hot nitric acid, which dissolves the lead, but leaves the antimony in the state of a white powder, which is sesquioxide of antimony. The supernatant liquor should then be carefully decanted, and the residuum being washed, dried, and ignited, may then be weighed as we said. The filtered liquor which contains the lead in the state of nitrate, may next be evaporated to dryness, the dry residuum being redissolved in water must now be converted into sulphate of lead by pouring a solution of sulphate of soda in the liquor. The white precipitate of sulphate of lead, being washed, dried, and ignited (without the filter) in a thin porcelain crucible, is then weighed—152 of sulphate of lead contain 104 of lead; or each grain of sulphate of lead contains 0.68287 of lead.

8. The presence of *iron* in antimony is detected by finely pulverizing a small portion of the metal, and then treating it by aqua regia, which will dissolve the whole. The solution is then diluted with a large quantity of water, which will precipitate nearly all the antimony in the shape of a bulky white precipitate, which is a basic chloride of antimony, that is, a compound of oxide and of chloride of antimony. The liquor is then filtered in order to separate the precipitate,

and a current of sulphuretted hydrogen is then passed through the filtrate in order to precipitate, as sulphuret of antimony, the last portions of antimony which are contained in the clear filtrate in the state of acid chloride of that metal.



The sulphuret of antimony thus produced, should be separated by filtering; the filtrate should be boiled until all odour of sulphuretted hydrogen has escaped; after which the presence of iron may be detected therein by means of a solution of ferrocyanide of potassium, which will produce a blue precipitate, or by supersaturating it with ammonia, and then adding hydrosulphuret of ammonia, which will produce a black precipitate, if iron be present. Tincture of galls may also be used as a test for iron, but the free acid should first be neutralized by ammonia or some other alkali.

9. The presence of sulphur may be detected by testing the solution in aqua regia, by a solution of chloride of barium, or of nitrate of baryta, which will produce a white precipitate of sulphate of baryta, *insoluble in water and in acids*. If the proportion of sulphur is considerable, it agglomerates in yellow lumps whilst boiling the metal in aqua regia. These yellow lumps may be readily identified as sulphur, by inflaming them upon a strip of platinum, when they will burn with a blue flame, and with the characteristic odour of sulphurous acid (the odour of burning brimstone.)

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ALLOYS OF ANTIMONY AND TIN.

10. These alloys are employed in the manufacture of a great number of utensils, and as it is sometimes useful to determine the proportions of these two metals in the alloy, we shall give

here the best and easiest method at present known of effecting this object.

11. Dissolve a known weight of the alloy in muriatic acid to which a small quantity of nitric acid has been added, and when the metallic mass has dissolved, immerse a blade of pure tin in the liquor. This will precipitate the whole of the antimony in the form of a black powder, provided the liquor be kept at a gentle heat by means of a sand bath, and provided also the operator takes care to maintain an excess of acid in the liquor.

12. The antimony thus precipitated is then collected on a weighed filter, washed, and dried at a very gentle heat, and when quite dry it is weighed. The loss indicates the quantity of tin. But if the operator wishes to determine in a positive manner the quantity of tin by direct experiment, another quantity of the alloy, similar in weight to the first portion operated upon, is to be dissolved as before, and a blade of zinc being immersed in it will precipitate both the antimony and the tin. The precipitate of the two metals is then collected on a weighed filter, washed, and weighed, and from the weight obtained the operator subtracts that of the antimony obtained by the previous experiment; the remainder indicates the quantity of the tin.

13. When, however, the alloy contains copper, as is the case with the alloy called "*Britannia metal*," the precipitate produced by the bar of tin, or by that of zinc, should be treated by nitric acid in order to redissolve the copper contained in the precipitate; in fact, nitric acid may be resorted to for the purpose of separating most other metals from tin and from antimony, the two latter metals being thereby oxydized and left in an insoluble state, whilst the oxydes of the other metals are taken up by the acid from which they may be respectively precipitated and estimated subsequently.

14. Let us suppose, for instance, that the alloy contains antimony, tin, copper, and bismuth, which is actually the case with *Britannia metal*, which consists of about 100

parts of tin, 8 parts of antimony, 2 of bismuth, and 2 of copper. The operator should first separate the antimony and the tin, as indicated before; an excess of solution of carbonate of ammonia is then added to the filtrate, by which means the oxyde of bismuth will be precipitated, whilst the oxyde of copper will remain in solution; after the addition of the carbonate of ammonia, however, the whole should be left at rest for some time in a warm place in order that the oxyde of bismuth may completely settle, it is then collected on a filter, washed with water containing some carbonate of ammonia, until all the copper is eliminated. It is then dried, ignited, and weighed, 80 grains of oxyde of bismuth contain 72 of bismuth. The excess of carbonate of ammonia should next be volatilized by evaporation, and after adding a small quantity of pure ammonia, the protoxyde of copper is then precipitated by solution of potash, moderately boiled in water in order to agglomerate the oxyde which should then be collected on a filter, and washed with hot water in order to eliminate the potash thoroughly. The oxyde of copper is then dried and ignited with the filter in a platinum crucible, and weighed immediately after cooling. 100 grains of protoxyde of copper = 80 grains of copper.

AQUAFORTIS.—See *Nitric Acid*.

AQUILA ALBA.—See *Calomel*.

ARGENTAN.—See *German Silver*.

ARGOL.—See *Bitartrate of Potash*.

ARNOTTO.—See *Annotto*.

ARQUIFOUX.—See *Alquifoux*.

ARROW-ROOT.

1. Arrow-root is a fecula which has a great analogy with common starch and with potato-starch ; but these two substances being cheaper, are often mixed with it. This admixture, however, can be easily detected, if at all large, by an attentive examination of the sample with the naked eye, or if in less considerable quantity, with the help of the microscope.

2. In effect the particles of potato-starch are of an irregular form, of various sizes, whilst arrow-root consists of particles of an even size and of an ovoid form, their surface being smooth and even. With respect to common starch, its presence may be detected, because it consists of particles of a larger size and of a dull appearance when examined through the microscope, whilst the particles of arrow-root are bright, pearly, and finer. The admixture of potato-starch in arrow-root imparts to it an acrid, earthy, unpleasant flavour, but this is by no means a test to be depended upon, because badly manufactured arrow-root acquires sometimes an unpleasant flavour from the resinous matter contained in the cuticle of the plant from which it is prepared, and which no subsequent stage of the manufacture can remove. Yet as the paste which arrow-root forms with water is inodorous, whilst that made from common starch and from potato-starch has a peculiar odour, the presence of the latter may thus be generally distinguished.

3. The best method, however, of detecting the spurious article, consists in triturating one part of the suspected sample with $1\frac{1}{2}$ or 2 parts of concentrated muriatic acid, or with dilute nitric acid of the strength of common aquafortis (specific gravity 1.10), which will immediately produce a transparent jelly, or mucilage, if flour or potato-starch is present ; but if the arrow-root is pure, the mucilage produced by that treatment is white and opaque. Ground rice, how-

ever, behaves with that re-agent exactly like arrow-root, from which it can be distinguished only by the microscope, the particles of rice having a sharp, spicular, horny appearance which can hardly be mistaken.

4. Potato-starch may be also easily detected by mixing the suspected arrow-root with muriatic acid. Genuine arrow-root so treated gives no odour whatever, but when adulterated with potato-starch an odour resembling that of beans is evolved.

ARSENIC.—See *Arsenious Acid*.

ARSENIO-SULPHURET OF COBALT.—

See *Cobalt Ores*.

ARSENIO-SULPHURET OF NICKEL.—See *Speiss*.

ARSENIURET OF NICKEL.—See *Kupfer Nickel*.

ARSENIOUS ACID.

ARSENIC. WHITE ARSENIC. WHITE OXYDE OF ARSENIC.

1. The substance commonly known under the name of arsenic is arsenious acid. It is a white, nacreous, opaque, compact, brittle substance, with a conchoidal fracture, completely volatilizable by heat, but *without emitting any odour of garlic*, except it be heated in contact with charcoal or other organic matter capable of reducing it into metallic arsenic, the odour of garlic belonging only to the fumes of metallic arsenic. Pulverized arsenious acid is a white powder.

2. Arsenious acid is most virulently poisonous, and its best solvent is muriatic acid, but it is also sparingly soluble in water. The solutions of alkalies and of alkaline carbonates dissolve arsenious acid also.

3. The arsenious acid of commerce, when pulverized, is sometimes adulterated with white sand, chalk, or plaster, but these impurities are most readily detected and their proportion estimated, for arsenious acid being entirely volatilizable by heat, it is sufficient to expose a given weight of the substance to a sufficient heat (380° or 400°) in a crucible; the whole of the arsenious acid will evaporate, but the above impurities will remain behind as a fixed residuum, and may then be weighed after cooling. The volatilization of the arsenious acid in the above experiment should be carried on under the hood of a chimney with a good draught, the fumes being exceedingly poisonous.

ASA FCETIDA.

1. Asa foetida is a gum resin of a light yellow colour when fresh gathered, but which becomes brownish by keeping. It is obtained by incision from the root of a plant (*ferula asafetida*), found chiefly in Persia and Scinde, and the juice is inspissated.

2. Asa foetida is in agglutinated more or less voluminous masses, of a brownish or drab colour variegated with white or violet specks; it has a strong and very disagreeable odour and taste resembling that of garlic, the fresher it is, the stronger are the smell and other properties of the resin which should be chosen clean, fresh, of a strong odour, and of a reddish brown colour. A gentle heat, even the warmth of the hand, is sufficient to soften asa foetida, and when set fire to, it burns vividly with a pure white flame, like camphor.

3. This gum-resin is frequently adulterated with gums of

an inferior price, with chalk, clay, sand, &c. All these impurities may be detected by dissolving a given weight of the gum in a mixture of alcohol, and of an acid, or of an alkali, the impurities are then left in an insoluble state, and their amount may be determined by weighing. The insoluble portion in the genuine gum should not exceed 15 or 16 per cent.

4. The specific gravity of *asa foetida* is 1.327.

ASHES.

1. In the countries where wood, being abundant, is used for fuel, the ashes resulting from its combustion are employed for washing, on account of a small quantity of carbonate of potash which they contain.

2. In commercial language, the term ashes is applied to the ashes of vegetable substances from which the alkalies known as potash, pearlash, barilla, kelp, are obtained.

3. Ashes being valuable only for the quantity of alkaline salt which they contain, it is important to determine its amount, which may be done exactly in the manner that has been described in the article on alkalimetry for the estimation of potash, or of soda-ash; ashes being, in fact, a mass containing a very small per centage of alkali mixed with a large quantity of earthy matter, and should be examined accordingly.

4. The operator should, therefore, take 1000 grains in weight of the ashes, and boil them for about ten minutes with seven or eight times their weight of water: the whole must then be thrown on a filter in order to separate the insoluble portion, which should be washed thereon until the water which filters ceases to tinge turmeric paper brown. The whole of the liquor which has filtered, is then examined with test-sulphuric acid of a known strength, exactly as has been described in the article on Alkalimetry.

5. The ashes of all species of woods and of weeds containing some alkali, as we said before, may be most beneficially employed as manure, especially in connection with bone-dust, or acid-phosphate of lime, or guano.

AZOTIC ACID.—See *Nitric Acid*.

AZURE-BLUE.—See *Smalt*.

AZURITE.—See *Copper Ores*.

BALSAM COPAIBA.—See *Copaiba*.

BARILLA.

1. Barilla is the name of an impure soda imported from Spain, Teneriffe, and the Levant. It is obtained in those countries by burning different plants that grow on the seashore, principally *salsola soda*. The ashes so obtained are lixiviated, evaporated, and then reduced into masses more or less rich in alkali. Barilla seldom contains more than 20 per cent of real alkali. The manufacture of barilla and of kelp (see *Kelp*) has become almost null since the invention by which Le Blanc succeeded in artificially manufacturing soda from common salt.

2. The determination of the commercial value of barilla is performed as we have described in the article on Alkalimetry.

BASTARD SAFFRON.—See *Safflower*.

BEER.

1. Beer and ale are liquors too well known to require description. The Act 56 Geo. 3 cap. 58 stipulates that:—

2. “No brewer, or dealer, or retailer of beer, shall receive, or have in his possession, or make, or use, or mix with, or put into worts or beer any liquor, extract, calx, or other material or preparation for the purpose of darkening the colour of worts or beer, or any liquor, extract, calx, or other material or preparation other than brown malt, ground or unground as commonly used in brewing ; or shall receive or have in his possession, or use, or mix with, or put into any worts or beer, any *molasses, honey, liquorice, vitriol, quassia, cocculus Indicus, Grains of paradise, Guinea-pepper, or opium, or any extract or preparation of molasses, honey, liquorice, vitriol, quassia, cocculus Indicus, grains of paradise, Guinea-pepper, or opium, or any article or preparation whatsoever* for, or as a substitute for malt or hops, upon pain that all such liquor, extract, calx, molasses, honey, vitriol, quassia, cocculus Indicus, grains of paradise, Guinea-pepper, opium, extract, article and preparation as aforesaid, and also the said worts and beer shall be forfeited, together with the casks, vessels, and other packages, and may be seized by any officer of excise ; and such brewer of, dealer in, or retailer of beer so offending shall for each offence forfeit £200.

3. “No druggist, or vendor of, or dealer in drugs, or chemist, or other person whatever, shall sell, send, or deliver to any licensed brewer of, or dealer in, or retailer of beer, knowing him to be so licensed, or reputed to be so licensed, or to any other person, for, or on account of, or in trust for, or for the use of such brewer, dealer, or retailer, any colouring from whatever material made, or any other material or preparation, other than unground brown malt, for the purpose of darkening the colour of worts or beer, or any liquor or preparation heretofore, or hereafter made use of for darkening the colour of worts or beer, or any molasses, or other articles

as mentioned in the first section, for, or as a substitute for malt or hops respectively ; and if any druggist, or vendor of, or dealer in drugs, or any chemist, or other person whatever shall so do ; all such liquor called colouring, and material or preparation for the purpose aforesaid, and liquor and preparation used for darkening the colour of worts or beer, molasses, and article or preparation to be used as a substitute for malt or hops, shall be forfeited, and may be seized by an officer of excise, and the druggist, vendor, dealer, chemist, or other person so offending shall forfeit £500.

4. By the Act 1 Will. IV. c. 51, for the repeal of the ale and beer duties, it is enacted, § 17, "That no brewer shall have in his brewery, or in any part of his entered premises, or in any mill connected with such brewery, any raw or unmalted corn or grain ; and all unmalted corn or grain which shall be found in such brewing premises or mill, and all malted corn or grain with which such unmalted corn or grain may have been mixed, shall be forfeited, and may be seized by an officer, with all vessels or packages in which such raw or unmalted corn or grain shall be contained, or in which such unmalted corn or grain, and the malted corn or grain with which the same may have been mixed shall be contained ; and every brewer shall for every such offence forfeit £200."

5. This then is the law. In theory, it seemingly provides for every thing ; in practice, it is a dead letter. It is a well-known and authenticated fact that many dealers in, or retailers of beer, in the verbose phraseology of the Act, have in their possession, and do make use of, mix with, or put into their beer, liquors, extracts, preparations, calx, and all manner of substances, except brown malt. It is a publicly known fact that carts may be seen bearing the inscription, in staring paint, of '——, brewers' druggist.' Such a cart I have myself seen, a few days ago, standing in broad daylight, at midday, before a publican's shop or gin-palace. Of course I do not know what the contents of the cart were, nor

whether it contained anything, but since the inscription painted upon it indicated the trade of the owner to be that of a *brewers' druggist*, it may fairly, I think, be inferred that the man was a dealer in drugs for the use of, dealers in or retailers of beer, spoken of in the Act; that the publican was probably a customer of his, or that endeavours were made to induce him to become one; at any rate, the above facts prove that, since there are beer druggists, there must be beer druggers; consequently, that if the purpose of the Act be useful, the Act itself is powerless, and that some more efficient protection should be resorted to.

6. This supineness is so much the more extraordinary that the guardians of this law are the Excise; not that we should complain of the unusual torpidity of the Hon. Commissioners in this instance; for when we consider that, if the provisions of the law were enforced, it must be done through a body of officers, many of whom are celebrated neither for their knowledge or discrimination, nor yet for their sobriety, candour, or morality, we would rather, for our own part, put up with the frauds of unprincipled dealers, than owe their repression or prevention to the maintenance and support of an army of subaltern officials, whose interest it is always to suppose fraud (for, according to law, all penalties and seizures are divisible, in equal parts, between the crown and the informer), and who, where fraud does not exist, may thus sometimes be induced to get up and fabricate cases through love of lucre, praise, or mischief—

“Pejor medicina malo.”

7. In our opinion, the prevention of the adulteration of articles of food is not, and should not be made a matter of fiscal regulation, but one of public hygien, irrelevant of the Board of Excise or of the inland revenue, and which should come within the province of a Board of Health, composed of gentlemen of high scientific attainments, and in every way

capable of judging dispassionately from *their own examination* of the suspected articles, and not, as is the case elsewhere, from the reports of menials, of various shades or grades of questionable honour and capacity, whom it is held a duty, *par esprit de corps*, to support at all hazards, and sometimes against all reason, sense, science, evidence, or justice.

8. We say that the guardianship of the public health should be placed in the custody of persons alike disinterested, and of high standing in point of probity and of scientific attainments ; and whether all the servants of the Hon. Board of Excise present the conditions of fairness, of morality, and of self-respect, which should be required of people whose declarations once made or reported to the Hon. Board become omnipotent, because immediately credited and supported, whether right or wrong, thus implicating the character and fortune of the trader, may be learned from the following paragraph in the celebrated pamphlet of George Combe, on the Constitution of Man, which we reproduce here, for the edification of our readers :—

9. “ A gentleman who was subject to the excise laws, fifty years ago, described to me the condition of his trade at that time. The Excise officer, he said, regarded it as an understood matter, that at least one half of the goods manufactured, were to be smuggled without being charged with duty. But then, said he, they made us pay a moral and pecuniary penalty that was at once galling and debasing. We were constrained to ask them to our table at all meals, and place them at the head of it in our holyday parties. When they fell into debt, we were obliged to help them out of it ; when they moved from one house to another, our servants and carts were in requisition to transport their effects. By way of keeping discipline upon us, and also to make a show of duty, they chose every now and then to step in and detect us in a fraud, and get us fined. If we submitted

quietly, they told us that they would make us amends by winking at another fraud, and they generally did so ; but if our indignation rendered passive obedience impossible, and we gave utterance to our opinions of their character and conduct, they enforced the law on *us*, whilst they relaxed it on our neighbours,—and these, being rivals in trade, under-sold us in the market, carried away our customers, and ruined our business. Nor did the bondage end here. We could not smuggle without the aid of our servants ; and as they could, on occasions of any offence given to themselves, carry information to the head quarters of Excise, we were slaves to them also, and were obliged tamely to submit to a degree of drunkenness and insolence that appears now to me perfectly intolerable. Further, this evasion and oppression did us no good ; for all the trade were alike, and we just sold our goods so much the cheaper the more duty we evaded ; so that our individual success did not depend upon superior skill and superior morality, in making an excellent article at a moderate price, but upon superior capacity for fraud, meanness, sycophancy, and every possible baseness. Our lives were any thing but enviable. Conscience, although greatly blunted by practices that were universal, and viewed as inevitable, still whispered that they were wrong ; our self-respect very frequently revolted at the insults to which we were exposed ; and there was a constant feeling of insecurity from the great extent to which we were dependent upon wretches whom we internally despised. When the government took a higher tone, and more principle and greater strictness in the collection of the duties were enforced, we thought ourselves ruined. The reverse, however, has been the case. The duties, no doubt, are now exceedingly burdensome from their amount ; but that is their least evil. Were it possible to collect them from every trader with perfect equality, our independence would be complete, and our competition would be confined to superiority in morality and skill. Matters are much nearer this point now than they

were fifty years ago ; but still *they would admit of considerable improvement.*"

10. There is no doubt of that.

11. After this creditable specimen of Excise management, is it surprising that people should surmise, as I have often heard it said, that possibly the oblivion in which the Act of Parliament regulating the matter of the present article is left, may be due to some compromise of the same kind, and wonder whether the explanation may not be found in demulcent potions, or golden collyriums judiciously offered and taken ? However this may be, the detection of most of the preparations mentioned in the Act, some of which are poisonous, cannot, in the present state of science, be always satisfactorily accomplished.

12. The presence of *lime*, or of *magnesia*, which is sometimes added to neutralize the acidity of beer, is detected in the same manner as when these substances are added to wine. (See *Wine*.)

13. If it contains common salt, which is almost generally found in beer in considerable and unwarrantable quantities, for the purpose doubtless of increasing the thirst of customers and inducing them to consume larger quantities of the liquid than they otherwise would, its presence may be detected, and its quantity estimated, by means of a solution of nitrate of silver, which in that case produces a precipitate which is insoluble in water and in nitric acid. The precipitate may then be washed, dried, fused in a small porcelain crucible, and weighed. 134 grains of chloride of silver = 60 grains of common salt.

14. Sulphate of iron (green copperas) is sometimes added to beer for the purpose, it is said, of *creating a head* ; but whether for this or any other purpose, it is a dangerous addition, which has, to my certain knowledge, created vomiting, cholic, and other symptoms of gastro-intestinal irritation. In order to detect the presence of this

salt, the beer should be decolourized as much as possible by animal charcoal, filtered, and the filtrate being tested by hydrosulphuret of ammonia, will then produce a black precipitate; by ferricyanide of potassium a blue precipitate.

15. On the other hand, if a solution of chloride of barium be added to another portion of the filtrate, a white precipitate of sulphate of baryta will be produced, which may be filtered, washed, dried, ignited, and weighed. 117 grains of sulphate of baryta represent 139 grains of crystallized protosulphate of iron.

16. The presence of opium may be detected as follows: The suspected beer is first to be decolourized as much as possible, by animal charcoal; a portion of the filtrate is then poured into a conical glass, and a few drops of acetate of lead are poured in. In the course of about twelve hours or sooner, a precipitate will be produced, especially by stirring the whole from time to time, which is a meconate of lead. The precipitate which will have collected at the bottom of the test-glass is then separated from the supernatant liquor by careful decantation, and 30 or 40 drops of sulphuric acid, and a like quantity of protosulphate of iron are then poured on the meconate of lead at the bottom of the test-glass. By this treatment the meconate of lead is decomposed and converted into sulphate of lead, whilst the liberated meconic acid, re-acting upon the protosulphate of iron, produces a beautiful red colour.

17. The presence of lead or of copper is detected in beer exactly in the same manner as in *wine*, which see.

18. Oxalate of ammonia, nitrate of baryta, of silver and acetate of lead, should only produce slight precipitates when poured in either ale or beer, and chloride of platinum should render it only slightly turbid.

BEES' WAX.—See *Wax*.

BELL METAL.—See *Bronze*.

BENJAMIN.—See *Benzoin*.

BENZOIN.

BENJAMIN. FRANKINCENSE.

1. Benzoin is a resin extracted by incision from a tree (*styrax benzoin*), and is met with in commerce in large, irregular, brittle lumps; its fracture offers a mixture of white, red, and brown veins or spots of various sizes, but the worst quality called *foot*, is almost exclusively brown, and full of vegetable stalks, sand, and other impurities.

2. The best quality, when broken, has the appearance of white marble, but is seldom met with.

The value of the article may be estimated from the quantity of benzoic acid obtained.

3. Good benzoin contains from 15 to 18 per cent. of benzoic acid, which, according to Stoltze, may be extracted as follows:

4. Dissolve a given weight of the resin in three parts in weight of alcohol, pour the solution into a retort, and add thereto a solution of carbonate of soda in eight parts of water, with three parts of alcohol, until the alcoholic solution of the benzoin is exactly neutralized, that is, until it ceases to have an acid reaction, which is known when it begins to turn reddened litmus paper blue. A quantity of water, equal to double the weight of the resin operated upon, is then added to the liquor, the alcohol is distilled off, and the liquor which remains in the retort contains the benzoic acid and the resin. The latter is removed by decanting the liquor, and washed; on weighing it, it is found to be equal to 80 or 82 per cent. of the benzoin employed, if pure. The liquor decanted from

the resin is then treated by dilute sulphuric acid, in order to precipitate the benzoic acid, which may be collected on a filter, well washed with cold water, and weighed.

5. But the value of benzoin may also be ascertained by the quantity of benzoic acid obtained from it by sublimation. Several processes may be employed, but that described by M. Hatchett is perhaps the most easy. It consists in digesting a given weight of the benzoin in sulphuric acid, and then by applying heat, a sublimate of benzoic acid is obtained.

BENZOIC ACID.

FLOWERS OF BENZOIN.

1. Pure benzoic acid is white, but it often has a brownish tinge, owing to the presence of a certain quantity of resin, which sometimes is considerable. Pure benzoic acid is odourless, but it generally has a slight odour of incense or of vanilla, especially when it has been obtained by sublimation, which is generally the case. It should volatilize completely when heated, and be entirely soluble in alcohol, and likewise in boiling water, but the latter solution on cooling stiffens into a solid mass, because the acid is only sparingly soluble in cold water. Benzoic acid is also dissolved by a solution of potash and by lime water, from which solutions it may be immediately reprecipitated by an addition of muriatic acid. These reactions are peculiar, and enable the operator to separate easily any impurities or admixtures which may contaminate this article.

2. When benzoic acid contains resin, it often exhales an odour of prussic acid when boiled with nitric acid, and the benzoic acid which crystallizes in cooling, instead of a feebly acid, has a bitter taste.

BICARBONATE OF POTASH.

1. This substance is often adulterated, or mixed with neutral carbonate of potash; sometimes, also, it contains chloride of potassium or of sodium, or sulphate of potash.

2. If the quantity of neutral carbonate is at all considerable, and provided chloride of sodium is absent, a solution of corrosive sublimate (perchloride of mercury), added to a moderately concentrated aqueous solution of the salt under examination, will produce a brick-red precipitate; whilst, if no neutral carbonate is present, only a slight precipitate, or turbidness, will appear.

3. Moreover, considering that bicarbonate of potash produces no precipitate in solutions of salts of magnesia, whilst the neutral carbonate of potash produces one, the presence of the latter substance may be readily detected by dissolving a portion of the sample in water and testing the liquor with a solution of sulphate of magnesia, which, if it form a precipitate, is carbonate of magnesia, and is due to the presence of neutral carbonate of potash.

4. Bicarbonate of potash is not deliquescent, except when it contains a portion of neutral carbonate of the same base.

5. If a portion of the sample, being dissolved in water and supersaturated with pure nitric acid, produces, when tested by solution of nitrate of silver, a white curdy precipitate, or only a turbidness, which is redissolved or disappears by adding an excess of ammonia, and is reproduced by an excess of acid, it is chloride of silver, and of course it proves that the bicarbonate operated upon contained chloride of potassium, or another soluble chloride. The chloride of silver may be collected on a small filter, washed, dried with care, fused in a porcelain crucible, and then weighed—144 of chloride of silver = 76 of chloride of potassium, or 1 equivalent of any other chloride.

6. If sulphate of potash or of soda is present, it may be

detected by pouring into the solution of the sample, acidified with pure nitric acid, some nitrate of baryta, which, if it produces a white precipitate insoluble in water and in acids, is sulphate of baryta, and indicates that the sample of bicarbonate of potash is contaminated by, or adulterated with a soluble sulphate. The precipitated sulphate of baryta may then be collected on a filter, dried, ignited, and weighed; 117 of sulphate of baryta = 88 of sulphate of potash, or 72 of sulphate of soda, or 1 equivalent of any other soluble sulphate.

7. Bicarbonate of potash being entirely soluble in water, all that which may remain insoluble is an impurity.

BICARBONATE OF SODA.

1. Bicarbonate of soda is very often adulterated with *effloresced neutral carbonate of soda*, the presence of which is detected by testing the solution, moderately concentrated, with one of perchloride of mercury (corrosive sublimate); if an orange red precipitate is produced thereby, it is a sign of the presence of a neutral carbonate; if, on the contrary, no neutral carbonate is present, the solution of perchloride of mercury will only produce a slight white precipitate or turbidness. The presence of the neutral carbonate may be detected also by means of solution of sulphate of magnesia which is not precipitated in the cold by one of bicarbonate of soda; whilst the neutral carbonate immediately produces a white precipitated of subcarbonate of magnesia. The other impurities or sophistications of bicarbonate of soda are the same as those practised with bicarbonate of potash, and are detected in the same manner. (See the preceding article, *Bicarbonate of Potash*.)

BICHLORIDE OF MERCURY.—See *Corrosive Sublimate*.

BINOXALATE OF POTASH.

SALT OF SORREL.

1. This salt is obtained from the acid juice of certain plants (*oxalis acetosella*—*oxalis corniculata*, *rumex acetosa*, &c.), and is manufactured on a large scale in Switzerland and certain parts of Germany. This salt has an extremely acid taste, and when ignited, it emits very pungent acid fumes, but is not charred.

2. The binoxatate of potash of commerce is sometimes falsified with cream of tartar, and sometimes also with bisulphate of potash.

3. The presence of cream of tartar (tartrate of potash), or in fact of any other organic substance, is recognized, because, if present, it will be charred, and will emit a peculiar odour of burning bread when ignited in a platinum crucible, whilst pure binoxalate of potash, when so treated, emits only white and acid fumes, but is not charred. There remains after ignition a greyish residue, which is carbonate of potash. Cream of tartar may also be detected by boiling a portion of the binoxalate of potash under examination with concentrated sulphuric acid, by which it is decomposed and dissolved, a rapid disengagement of carbonic acid and of carbonic oxyde taking place at the same time, the solution, however, remaining colourless, if the salt be pure ; but if, on the contrary, after boiling the suspected salt for some time, as just said, the liquor turns black or brown, then it is a proof that tartaric acid, or an organic matter, is present.

4. The presence of bisulphate of potash is detected by dis-

solving a portion of the salt in pure water, and testing with solution of chloride of barium, which will produce a precipitate of sulphate of baryta insoluble in water and in acids.

B I S M U T H.

1. The bismuth of commerce is generally imported from Saxony, but it is smelted also in Bohemia, Carynthia, Sweden, and Norway ; England possesses also a few mines of that metal.

2. Bismuth being very fusible and generally found native, its separation from the *gangue* or matrix is exceedingly simple and easy. The ore is simply broken to pieces, put into a crucible, and exposed to a red heat. After a while, the metal is found agglomerated at the bottom of the crucible, or else the ore is charged in cylinders of cast iron, slightly inclined, and heated therein. The bismuth soon runs from its gangue and flows into pans which are placed at the lower end of the cylinder. Whichever way bismuth is obtained, that of commerce is never pure ; it is contaminated by *sulphur*, *arsenic*, *lead*, *silver*, *iron*, *tin*, &c. : the analysis of the metal may be performed, as follows :—

3. Put into a crucible a given weight of the bismuth to be examined, and fuse it therein with one-tenth part of its weight of nitrate of potash, in order to convert the *sulphur* and the *arsenic* into sulphate and arseniate of potash, which may then be eliminated by washing with water ; these compounds being soluble in this menstruum.

4. The bismuth which is now left, and which may contain *lead*, *silver*, *tin*, &c., is boiled in nitric acid, which oxidizes the tin and leaves it in an insoluble state ; it may then be collected on a filter, washed, ignited, and weighed.

5. The filtrate should next be treated by a slight excess of solution of carbonate of potash, a solution of cyanide of pot-

tassium is then added, and the whole is digested at a gentle heat for some time. The lead and the bismuth which have been precipitated by the carbonate of potash are left in an insoluble state, but the silver is taken up and remains in solution in the state of double cyanide of silver and of potassium. The whole is thrown on a filter; the carbonate of lead and of bismuth on the filter may then be dissolved in acetic acid, and a blade of pure lead, previously weighed with great accuracy, should be completely immersed in the acetic acid solution. The flask, containing the solution and the blade of lead immersed therein, is to be corked up, and the whole is left at rest for several hours. The bismuth is gradually thrown down in the metallic state by the lead, and when the whole of the bismuth has separated, the blade of lead is removed, washed, dried, and weighed. The bismuth is then collected on a filter, washed with pure water (previously boiled and cooled out of the contact of the air); it is then redissolved in nitric acid, and an excess of a solution of carbonate of ammonia is then poured in; the whole is heated for a short time, by which means the oxyde of bismuth is completely separated; it is then washed, dried, ignited in a porcelain crucible, and weighed. The filter should be burnt separately on the cover of the crucible, and the ashes are returned to the mass to be weighed.

6. The solution of lead which was filtered from the precipitated bismuth is neutralized with ammonia and treated by oxalate of ammonia in order to precipitate the lead in the state of oxalate of lead, which is then collected on a filter, washed, and ignited in a small, open, and counterpoised porcelain crucible, by which treatment it is converted into protoxyde of lead, from which the weight of the lead in the compound may be calculated. The loss of weight sustained by the blade of lead employed indicates how much oxyde of lead should be subtracted from the total weight of the protoxyde of lead obtained. 112 parts in weight of protoxyde of lead = 104 of metallic lead.

7. The filtrate separated from the precipitate at first produced by carbonate of potash, and which contains the silver in the state of double cyanide of silver and potassium, should be mixed with an excess of dilute nitric acid, and gently heated; the silver is thereby precipitated in the state of cyanide of silver which is collected on a filter, washed, dried at a steam heat, and weighed. 100 grains of cyanide of silver = 80.6 of silver.

8. Silver may also be readily separated by cupellation. (See the article on *Silver*.)

BITARTRATE OF POTASH.

SUPERTARTRATE OF POTASH. ARGOL. CRUDE TARTAR.
CREAM OF TARTAR.

1. Bitartrate of potash, as found in commerce in the state of a crystalline incrustation which is deposited in wine casks is called argol, and when purified by solution and recrystallization it is called *cream of tartar*.

2. Bitartrate of potash is sometimes adulterated by *pulverized quartz* or *sand*, by *chalk*, or *calcareous spar*, or by *alum*, and by *bisulphate of potash*.

3. If *sand* is present, it may be detected by boiling a given quantity of the tartar under examination, with half its weight of carbonate of potash or of borax, in water. The sand, if any is present, will be left in an insoluble state.

4. If the sample of bitartrate of potash contains any *carbonate of lime*, an effervescence will be produced by pouring diluted muriatic acid upon a portion of the sample, which effervescence is owing to the disengagement of carbonic acid. On the other hand, the presence of *lime* may be detected in the muriatic acid solution, by first neutralizing the acid with ammonia, and then testing the solution with oxalate of ammonia, which will then produce a white precipitate of

oxalate of lime. This precipitate should be separated by filtering, washed, dried, and ignited; ignition converts it into carbonate of lime, in which state it may be weighed.

5. It should be borne in mind, however, that even purified bitartrate of potash is often contaminated by a small quantity of tartrate of lime; that of commerce, however, contains the latter substance in various proportions, from 5 to 7, and even 14 per cent.

6. White argol is less impure than red argol.

7. When bitartrate of potash has been adulterated with *alum* or with *bisulphate of potash*, it may be detected by dissolving a portion of it, and testing the solution with one of chloride of barium. If a white precipitate is thus produced, insoluble in water and in acids, it is sulphate of baryta, from which the amount of the above impurities may then be estimated as follows:—the precipitated sulphate of baryta is collected on a filter, washed, dried, and ignited, after which it is weighed; 117 gr. of sulphate of baryta represent 474 gr. of crystallized alum, or 146 gr. of bisulphate of potash. But whether the precipitate of sulphate of baryta produced as above directed, was owing to the presence of alum, or to that of bisulphate of potash, may be known in the following manner:—if an aqueous solution of ammonia, or of carbonate of ammonia, being poured in the solution of the bitartrate of potash under examination, produces a white flocculent precipitate, insoluble in any excess of the precipitant, soluble in caustic potash or soda, it is hydrate of alumina, and it is, of course, a proof that alum is present. The precipitated hydrate of alumina may further be washed with hot water, dried, ignited, and then weighed; 50 grains of alumina represent 474 of crystallized alum. If, however, the addition of ammonia to the original solution has failed in producing a precipitate, and yet one was produced when tested with chloride of barium, then it was due to the presence of a soluble sulphate.

BLACK BAND.—See *Iron Ores*.

BLACK JACK.—See *Zinc Ores*.

BLACK LEAD.

PLUMBAGO. GRAPHITES.

1. Black lead is a species of carbon of a dark steel grey colour and of a metallic lustre, soft, with a greasy feel, and leaving a metallic stain when rubbed on paper. The best qualities of this material are used for making pencils and for the electrotpe ; the inferior qualities are used for making crucibles, for diminishing friction by spreading it on certain surfaces instead of oil or grease ; and for brightening or giving a lustre to stoves and other utensils or articles.

2. Black lead is adulterated to an enormous extent with *sulphuret of antimony*, *micacious iron ore*, but more particularly with *lamp black*. An extraordinary quantity of this substance is sold in small packets *for the use* of servants for the purpose of brightening iron stoves, and some of these packets are adulterated with as much as from 50 to 60 per cent. of lamp black !

3. These sophistications, however, may be easily detected in various ways : first by pouring muriatic acid upon a portion of the sample, this will dissolve the *sulphuret of antimony*, if any be present, and will leave the black lead in an insoluble state. The whole is then thrown upon a filter which retains the black lead, and if, on adding water to the filtrate, a milkiness or a white precipitate is produced, it is due to the presence of antimony, which may further be identified by first adding a certain quantity of tartaric acid to the filtrate, after which water may be added without producing any

miliness or precipitate, and if a current of sulphuretted hydrogen, being now passed through the diluted liquor, produces an orange-red precipitate completely soluble in hydrosulphuret of ammonia, then the presence of antimony is rendered conclusive. The stream of sulphuretted hydrogen must be passed through the liquor until it smells strongly of sulphuretted hydrogen. (See the apparatus, page 2.) The orange-red precipitate may be collected on a weighed filter, washed with pure water, and dried at a very gentle heat until it ceases to lose weight, and it is then definitely weighed as sulphuret of antimony. It is advisable to add tartaric acid before diluting with water, in order that the solution should not turn milky, because, if sulphuretted hydrogen were passed through the turbid solution, a portion of the antimony might escape its action, and thus give an incorrect estimate.

4. The proportion of *lamp-black* may be estimated for technical purposes by weighing a portion of the sample, and keeping it at a cherry-red heat in a platinum crucible, constantly stirring it during the ignition until it no longer loses weight. The loss of weight indicates the proportion of lamp-black, the latter being easily burnt at the temperature above indicated, but which is quite insufficient to ignite the black lead.

5. Whether *micaceous iron* has been added, may be detected by mixing a given weight of the sample with about three times its weight of carbonate of potash, and fusing the whole in a crucible. The fused mass should then be lixiviated with water, supersaturated with muriatic acid, and evaporated to dryness. The dry mass may now be digested with water and filtered. The filtrate, being treated with aqueous solution of ammonia, will yield a reddish brown precipitate which should be collected on a filter, washed, dried, ignited, and weighed. The weight of this reddish brown precipitate should never exceed 13 per cent.

6. Black lead is sometimes contaminated by *sea salt*, which

renders it unfit for the making of crucibles, this impurity is detected by boiling a portion of the sample with pure distilled water, filtering and testing the filtrate with solution of nitrate of silver, which will then produce a white curdy precipitate, or only a turbidness, if the quantity of sea salt is inconsiderable. The sea salt with which the black lead is contaminated may be very easily eliminated by washing it with a large quantity of water; and, after allowing the black lead to subside, the clear water is poured off, and the black lead may then be dried.

BLANC MANGE.

BONBONS. SWEETMEATS. LIQUEURS. LOZENGES, &c.

1. In this article we intend to call the reader's attention to the various preparations called *bonbons*, *sweetmeats*, *liqueurs*, *lozenges*, &c., which, when coloured with mineral substances, are the immediate cause of the most distressing accidents.

2. The "Northampton Herald" of June 10, 1848, published an article stating, that on Thursday, the 8th of the same month, much alarm prevailed in the town in consequence of a report that a number of persons who had dined the previous day at a public dinner in the New Hall, had been poisoned by partaking of some blanc mange, and that one of them had died. The report unhappily proved correct, Mr. Wm. Cornfield having expired soon after five o'clock that morning, and several other persons being then seriously ill and under medical attendance.

3. The evidence brought before the county coroner proved, that some jelly, with a green cucumber ornament, had been served up, that all the persons who had partaken of the green portion had been more or less severely ill, and that it had been fatal to the gentleman above named; the chemical evidence established, that the green colouring had

been produced by means of the mineral pigment called *emerald green* (arsenite of copper).

4. The jury accordingly returned the following verdict:—

“We find that Wm. Cornfield died on the 8th of June, from the effects of a poison called arsenite of copper, or emerald green, carelessly and negligently administered in a blanc mange made by Edward Randall, and carelessly and negligently sold by Edmund Franklin, with the full knowledge that it contained a deadly poison.”

5. The “Chemical Times” of the 10th February, 1849, published the following statement of a case of poisoning by comfits coloured by arsenite of copper, reported by Dr. Walter Fergus, the resident medical officer at Marlborough College.

6. “A few days ago there was a party at a gentleman’s house here (Marlborough), at which there were a number of children. A magnificent cake was a prominent object, being profusely adorned with a variety of ornaments. The cake was cut up, and the ornaments were distributed amongst the juvenile portion of the guests. The children of one gentleman carried home, amongst others, a green flower made of sweet paste in imitation of a fuchsia. On the second day after the party, shortly before one o’clock, the eldest boy, about five years old, became very sick, and was purged. In about half an hour the second boy became sick; and in a few minutes the eldest child, a girl about seven years old, was similarly seized. I happened to be in the house at the moment of seizure of the two latter, and was at once strongly impressed that they had partaken of something poisonous. Inquiries were made, and the green flower was found minus two petals and a half. The great prostration, especially of the eldest boy, together with the nature of the other symptoms and circumstances, pointed strongly to arsenic as the cause of the disaster. I, therefore, immediately prepared and administered some hydrated peroxide of iron, and adopted other suitable

treatment. The vomiting and prostration continued very urgent till late in the evening with the elder children. Next morning they were found very much better, and are now all convalescent. I have since submitted a fragment of the flower to the black flux and reduction test, and obtained an abundant ring of metallic arsenic in the test-tube, fully confirming the idea I at first formed that arsenite of copper was the colouring matter of the flower, and the cause of what might have been a most serious calamity. The cake was purchased at a confectioner's in the town, and the ornaments having been procured by him from London, it is more than probable that a large quantity of these arseniuretted sugar flowers have been manufactured. It is, therefore, of great importance that the public should be made aware of the risk incurred in using these and similar articles of confectionery."

7. It is not, however, only in blanc mange or in comfits that the above poisonous substance is used; nor is arsenite of copper the only deleterious colouring matter employed through ignorance or carelessness. We unfortunately read now and then of serious mischief being done, and sometimes of death being caused by bonbons and other sweets coloured green, yellow, red, blue, &c., by emerald green, chromate of lead, or gamboge, red lead, blue verditer, &c.

8. The following substances should never, *under any pretence, nor in any quantity*, be used for colouring jellies, sweetmeats, &c., or any article of food whatsoever:—

GREEN—Emeral green	.	}	Arsenite of copper.
Scheele green	.	}	
Scweinfurt green	.		Acetate and arsenite of copper.
Green verditer	.		Hydrated, basic carbonate of copper.
Verdigris	.	.	Acetate of copper.
Rinman's green	.		Cobaltate of zinc.

YELLOW—Gamboge.

Chrome yellow .	Chromate of lead.
Orpiment . . .	Sulphuret of arsenic.
Patent yellow .	} Perchloride of lead.
Turner's yellow	
Cassel yellow .	

RED—Red lead . .	} Oxyde of lead.
Minium . . .	
Cinnabar . . .	} Sulphuret of mercury.
Vermillion . . .	

BLUE—Blue verditer . . Carbonate of copper and lime.

9. In fact, all mineral pigments, except Prussian blue, are more or less dangerous, and therefore should not be employed for colouring edible substances.

10. We beg to transcribe here the excellent regulations which were published by order of the “Préfet de Police” of Paris, under the date of the 10th of December, 1830. They are substantially as follow :—

“Considering that the colouring matter given to sweets, bonbons, liqueurs, lozenges, &c., is generally imparted by mineral substances of a poisonous nature, which imprudence has been the cause of serious accidents.

“That the same accidents have been produced by chewing or sucking wrapping-paper, glazed or coloured with mineral substances of a poisonous nature.

“Having read the Reports of the Board of Public Health :—

“It is expressly forbidden to make use of any mineral substance for colouring liqueurs, bonbons, sugar plums, lozenges, or any other kind of sweetmeats or pastry.

“No other colouring matter than of a vegetable nature, shall be employed for such a purpose, except gamboge and archil.

“It is forbidden to wrap sweetmeats in paper glazed or coloured with mineral substances.

“It is ordered that all confectioners, grocers, and dealers in liqueurs, bonbons, sweet-meats, lozenges, &c., shall have their name, address, and trade printed on the paper in which the above articles will be enveloped.

“All manufacturers and dealers are personally responsible for the accidents which shall be traced to the liqueurs, bonbons, and other sweetmeats manufactured or sold by them.”

11. The colouring substances which may be employed with perfect safety by confectioners, liqueur-makers, and others, for the purposes mentioned, are the following :—

12. BLUE COLOURS :—

Pulverized indigo.
Sulphate of indigo.
Prussian blue.

13. These substances are readily miscible with all the other colours in which blue forms a constituent part, as for example, with yellow to make green, and with red to make purple.

14. YELLOW COLOURS :—

Saffron.
Turkey yellow berries.
Persian yellow berries.
Quercitron.
Fustic.
Aluminous lakes of the above woods.

15. The yellow colour obtained from some of the above substances, and especially from Turkey yellow berries and Persian berries, is more brilliant than that imparted by chrome yellow, which is a poison.

16. RED COLOURS :—

Cochineal.

Carmin.

Carmin lake.

Brazil-wood lake.

Madder lake.

COMPOUND COLOURS.

GREEN COLOURS.

17. A green colour may be produced by mixing one of the blue colours with one of the yellow colours abovementioned, but the brightest green is that produced by Prussian blue and Persian berries ; the colour thus produced is as beautiful as Schweinfurt green, which is a poison.

PURPLE COLOURS.

18. A purple colour may be produced by mixing one of the blue colours with one of the red colours above mentioned ; any variety of tint may be thus obtained.

19. A decoction of logwood produces a good violet or purple colour.

20. A purple dahlia colour may be obtained by mixing carmine lake with Prussian blue.

21. As to the coloured papers which are sometimes used as wrappers, the most dangerous are those of a fine green or of a light blue colour, produced by means of metallic pigments, and which, when in contact with soft, moist, or greasy substances, such as lard, butter, cheese, sweetmeats, caramel, sugar-plums, &c., may impart to them a portion of their colouring matter, and thus be the cause of serious or even fatal accidents.

22. Dr. Rasedon, of Mersburg, has directed the attention of medical men to the danger of using Scheele's green, either in painting walls or in staining paper-hangings. He

thinks that by the agency of moisture a certain amount of arsenuretted hydrogen is evolved, which materially interferes with the purity of the air. According to Dr. Rasedon, pseudo-rheumatic pains, neuralgia, cough, lassitude, and emaciation, are produced by that state of the air, and these affections get worse with an increase of moisture either in the room or atmosphere. The government of Baden, acting upon this gentleman's suggestion, has prohibited the use of the arsenite of copper in the painting of rooms or paper, under a fine of from one to four pounds sterling. (It should be remembered, however, that in Silesia mortar is made by mixing a certain kind of arsenical sand with the lime, and that the people who inhabit houses for the building of which such mortar has been used, complain of none of the ailments above-mentioned.) The cases lately recorded at Marlborough and Tenterden ought to be a warning of the danger of using Scheele's green in cake ornaments.

23. The glazed paper and cards known as enamel paper, and cards such as are used now generally as cards of visit, are prepared with carbonate of lead (white lead), which is a deadly poison.

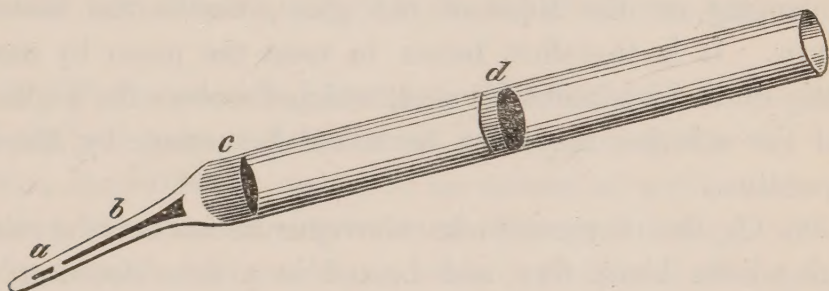
Detection of mineral colouring matter in sweetmeats, sugar-plums, and other edible substances.

24. All the mineral preparations abovementioned, being insoluble in water, may be isolated by digesting the suspected articles in water, which dissolves the sugar. The whole being left at rest, the insoluble matter settles at the bottom, and may be separated by decantation, filtering, washing, and drying at a gentle heat.

25. *Scheele's green*, or *emerald green*, or arsenite of copper, *Schweinfurt green*, which is a mixture of acetate and arsenite of copper, are easily recognized as arsenical compounds by the garlic odour which they evolve when thrown

upon ignited charcoal, or when mixed with carbonate of soda and heated before the blow-pipe upon charcoal.

26. The presence of arsenic may also be rendered evident in the following manner :—Take a glass tube, free from lead, and draw it to a point about one inch long, so that the internal diameter of that part be about the size of a strong knitting kneedle, as here represented.

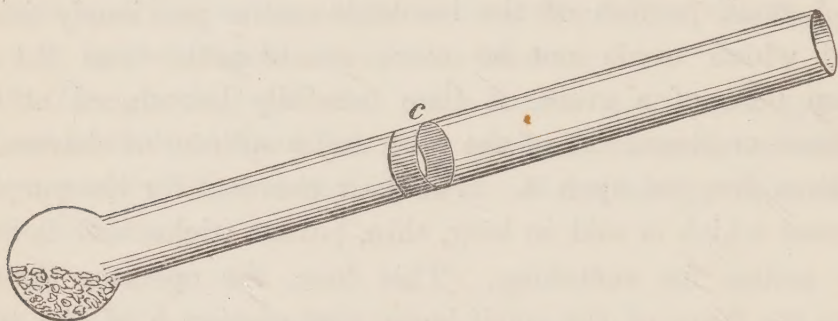


A small portion of the insoluble matter previously dried, and which needs not be more considerable than 0.1 or even 0.01 of a grain, is then carefully introduced at the bottom or closed end of the tube, and a splinter of charcoal *b*, is then dropped upon it. The best charcoal for the purpose is that which is sold in long, thin, porous sticks, and is used by artists for sketching. This done, the operator thrusts into the flame of the spirit lamp, that portion *b* of the tube where the charcoal lies, and when it becomes red-hot, he immediately heats the pointed part which contains the arsenical compound. The arsenious acid, in passing over the ignited piece of charcoal, is reduced, and a ring of metallic arsenic is first formed at *c*, which may be shifted to *d*, and then back again to *c*, by exposing these parts successively to the heat of the flame of the spirit lamp. The ring of metallic arsenic having been shifted back into *c*, the tube may be cut off at that point by a file, and on applying heat, the odour of garlic, which is characteristic, becomes immediately perceptible, and thus indicates the presence of arsenic beyond possibility of doubt.

27. Paper which has been coloured with Scheele's green,

may also be rolled up into a ball and introduced in the bulbous end of the tube represented in the succeeding paragraph, and treated in the same manner; the charcoal of the paper is sufficient to reduce the arsenic, and a metallic mirror is then obtained. It is difficult, however, to detect the presence of arsenic by treating the suspected paper in this manner, because an empyreumatic oil passes over with the fumes, and, condensing on the sides of the glass, masks the metallic mirror. It is therefore better to treat the paper by moderately diluted hydrochloric acid, which dissolves the pigment, and the solution may then be tested for arsenic by Marsh's apparatus.

28. Or the dry residuum abovementioned may be mixed with a little black flux, and heated in a tube closed at one end.



If arsenic is present, a metallic mirror of the metal will be formed at *c*.

29. If the powder which remains in an insoluble state, after digestion in water, contains any of the *oxydes of copper*, the addition of aqueous ammonia will produce a solution of a beautiful blue colour.

30. Paper which has been coloured with oxyde of copper is decolourized when touched with a solution of ammonia; or if the paper be put into a glass, and aqueous ammonia poured upon it, a solution of a beautiful blue colour is obtained. Moreover, paper which has been coloured with a salt of copper burns with a green flame.

31. Or the dry residuum, or the paper, may be treated by

dilute sulphuric acid and filtered. If a portion of the filtrate, being tested with ammonia produces a blue colour, or with solution of ferrocyanuret of potassium a reddish brown precipitate, it is a sign that copper is present. A bar of iron, perfectly bright and clean, such as for example the blade of a knife, is also an excellent test for copper ; the blade being plunged in the solution will, after a short time, become coated with metallic copper, if that metal be present.

32. If the colouring matter be *Rinman's green* (cobaltate of zinc), it may be ascertained by dissolving the dry residuum, insoluble in water, in an excess of acetic acid, and passing a stream of sulphuretted hydrogen through the solution, which will produce a white precipitate of sulphuret of zinc, whilst the cobalt will remain in solution. The white precipitate may be identified as sulphuret of zinc, by redissolving it in muriatic acid, and leaving it to digest until all odour of sulphuretted hydrogen has vanished, filtering, adding an *excess* of ammonia, which will redissolve the white precipitate at first produced by it, filtering again, if necessary, and adding hydrosulphuret of ammonia to the strongly ammoniacal solution, which will reprecipitate the zinc in the state of white sulphuret of zinc, which is insoluble in any excess of that re-agent. In fact, when a white precipitate is produced by hydrosulphuret of ammonia in a clear and colourless, strongly ammoniacal, or alkaline solution, it is always owing to the presence of zinc.

33. The liquor which was filtered from the white precipitate of sulphuret of zinc, produced in the first instance by the stream of sulphuretted hydrogen, and which contains the acetate of cobalt, has a pink colour, and yields by evaporation a deliquescent residuum of a purple or blue colour.

YELLOW COLOURS.

34. If chromate of lead has been used to impart a yellow

colour to the suspected article, it may be easily detected in the dry residuum mentioned before, as follows :—

35. A portion of the dry residuum should be mixed with fused borax, and if chrome is present, a bead of an emerald green colour will be obtained by fusion before the blowpipe. If, on the other hand, another portion of the residuum be mixed with soda, and heated upon charcoal in the reducing flame of the blowpipe, globules of lead will be obtained.

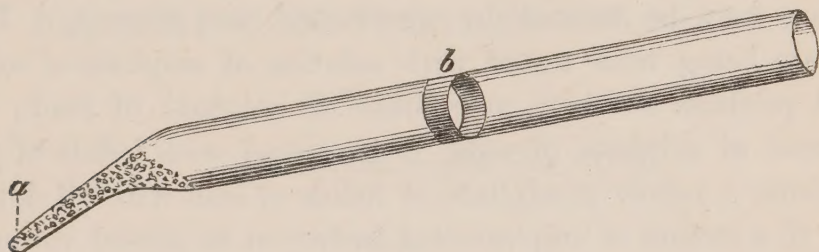
36. *Chromate of lead* may also be detected by boiling a portion of the dry residuum in solution of carbonate of potash, by which it becomes converted into chromate of potash of a light or lemon yellow colour. The addition of a few drops of nitric acid converts it into bichromate of potash, and the solution assumes an orange yellow colour. To a portion of this solution add a few drops of acetate or of nitrate of lead ; this will produce a beautiful yellow precipitate of chromate of lead, soluble in caustic potash. If, instead of nitrate or of acetate of lead, solution of nitrate of silver is employed, a carmine red precipitate of chromate of silver will appear ; if the solution does not contain an excess of acid, the precipitate is purple.

37. All the oxydes and salts of lead may be easily recognized by means of the blowpipe upon charcoal, because, when thus heated in the reducing flame, globules of metallic lead are immediately obtained. The reduction of lead is so easily effected, that ignition is of itself sufficient to accomplish it ; for if paper or cards, glazed or enamelled with carbonate of lead, are set fire to, the operator may observe, first, that near the inflamed point, a yellow coating is produced, which is oxyde of lead, and by looking carefully at the carbonized or charred portion of the paper, a great number of minute globules of metallic lead may be seen.

38. Carbonate of lead being a poison, it is of course dangerous to use paper enamelled or glazed with that substance, as wrappers for articles of food. There are examples

of children having been poisoned by chewing or sucking such cards.

39. The presence of *orpiment* is recognized in the dry residuum by heating a portion of it to redness on a strip of platinum foil, in which case it will burn with a pale blue flame, and evaporate completely. The best test, however, of the presence of orpiment, is its conversion into metallic arsenic, which is done as follows :—



The sulphuret of arsenic (*orpiment*,) or the dry residuum supposed to contain it, is placed at the end *a* of the tube in the annexed figure, and above it a suitable quantity of recently charred tartrate of lime is added. The portion of the tube containing the charred tartrate of lime, must be heated to redness by means of an argand spirit lamp, and when red hot, the end *a* of the tube containing the orpiment, is brought into the flame of the lamp. The fumes of the sulphuret of arsenic, traversing then the red hot mixture of lime and charcoal, are decomposed, the sulphur combines with the lime, forming sulphuret of calcium, oxide of carbon is disengaged, and a ring of metallic arsenic is deposited at *b*. Care must be taken that the charred tartrate of lime be hot enough, for the sulphuret of arsenic might otherwise be sublimed without decomposition. Instead of tartrate of lime, oxalate of lime, mixed with a little carbonate of ammonia, may be used.

40. *Gamboge* is recognized, because the solution of the sweetmeats under examination retains a yellow tinge, gamboge being partially soluble in water. The best method of

identifying this substance consists in digesting the sweetmeats in rectified alcohol, and adding water to the filtered alcoholic solution, by which the resin of that gum will be precipitated. If it be now moistened with ammonia, it will assume a red colour.

41. *Perchloride of lead, red lead*, and other preparations of lead, may be detected exactly in the same manner as *chrome yellow*, by the blowpipe, by which means a bead of metallic lead may be obtained; or the residuum spoken of before may be treated by nitric acid and filtered. The filtrate being then tested with solution of sulphate of soda, will produce a white precipitate of sulphate of lead; if, instead of sulphate of soda, it be tested with iodide of potassium, a yellow precipitate of iodide of lead will fall down. Or, if a stream of sulphuretted hydrogen be passed through the filtrate, a black precipitate of sulphuret of lead will be produced.

42. *Cinnabar, or vermillion*, may be detected by dissolving the residuum above mentioned in aqua regia, diluting with water, filtering and testing with chloride of barium, which will then produce a white precipitate of sulphate of baryta, the sulphur of the sulphuret of mercury (vermillion) having been converted into sulphuric acid by the action of the aqua regia. Remember, however, that sulphurets always yield a portion of sulphuric acid when treated by aqua regia or nitric acid, and therefore this test is not conclusive, except the absence of other sulphurets has been previously ascertained. Another way consists in mixing a portion of the red sediment with soda slightly moistened, and introducing the whole into a glass tube closed at one end. If the extremity of the tube be now exposed to a red heat, the mercury will be revived, and will sublime in the form of a grey coating, in which the presence of globules of mercury may be rendered apparent, if not already so, by rubbing with a glass rod. The vermillion may also be identified as such by heating it

without soda in the glass tube, when the vermilion will sublime, without alteration, in the form of a red powder.

43. We may add, in concluding this article, that toys are generally coloured or painted with poisonous substances of the same description as those mentioned, and that fatal accidents have happened from children having applied them to their mouths.

BLEACHING POWDER.—See *Chloride of Lime*.

BLENDE.—See *Zinc Ores*.

BLUE CARBONATE OF COPPER.—See *Copper Ores*.

BLUE COPPERAS.—See *Sulphate of Copper*.

BLUE VITRIOL.—See *Sulphate of Copper*.

BONBONS.—See *Blanc Mange*.

BORACIC ACID.

1. Boracic acid is found in an uncombined state in several small muddy lakes of Tuscany and of Sesso, called *lagoni*, in the midst of which small craters, called *suffioni*, are opening, and which disengage aqueous vapours charged with boracic acid, borate, and sulphate of ammonia, of iron, of lime,

and other salts, as is shown in the analysis of the boracic acid of Tuscany, by Payen, which we reproduce here :—

Pure crystallized boracic acid .	74.0 to 84.0
Sulphate of magnesia .	} 14.0 „ 8.0
„ of ammonia .	
„ of lime .	
Chloride of iron .	
Alum .	} 2.5 „ 1.25
Clay, sand, sulphur .	
Hygroscopic water disengaged at 35° centigrade }	7.0 „ 5.75
Nitrogenized organic matter }	} 2.5 „ 1.00
Sal ammoniac .	
Hydrochloric acid .	
Sulphuretted hydrogen .	
	100.0 100.0

2. According to the above analyses the boracic acid of Tuscany contains, therefore, from 16 to 26 per cent. of foreign matter.

3. The best way of estimating the value of boracic acid consists in combining it with a base, for example, with soda, and decomposing the borate thus formed by adding sulphuric acid, exactly as for the analysis of borax which we have described under that head.

BORATE OF SODA.—See *Borax*.

BORAX.

BORATE OF SODA. TINCAL. POUNXA. CRYSOCOLLA.

1. Borax is a combination of boracic acid with soda, which is found in, and is exported chiefly from, India, in an impure state, and is naturally covered with a kind of fatty

or soapy matter. In that impure state it is in hexaëdral crystals, more or less flattened, of a yellowish or green colour, and it is then known under the name of *tincal*, or of *crysocolla*; it is only after purification that it is called *borax*, it is then white, and in slightly efflorescent, irregular hexaëdral prisms, slightly styptic, and has an alkaline re-action on test-papers. Borax, however, is manufactured also by combining directly soda with native boracic acid. (See *Boracic Acid*.)

2. The assay of borax may be made very easily by a process contrived by Gay Lussac, and similar to that employed in alkalimetry. Since sulphuric acid decomposes borate of soda in a complete manner, if we employ sulphuric acid of a known strength, the quantity which will have been required to decompose a known weight of borax, will indicate the quantity of soda contained in the salt, and therefore, the proportion of borax which corresponds to that quantity of soda may be readily calculated.

3. The *modus operandi* is as follows :—

Dissolve 100 grains of the borax under examination, in about 1000 grains-measure of pure water, with the help of heat, and add thereto a few drops of tincture of litmus, so as to impart a blue tinge to the solution. This done, pour into an alkalimeter 1000 grains-measure of test-sulphuric acid of specific gravity 1.032 (1000 grains-measure contain 1 equiv. of dry acid, and can therefore neutralize 1 equiv. of each base, see *Alkalimetry*), and add it gradually to the solution of the borax. The solution at first assumes a vinous or purple hue, and at last, one or two drops of the test-sulphuric acid in excess change it into the characteristic red colour which indicates that the point of saturation is obtained. In order, however, to detect this change of colour more easily, M. Gay Lussac recommends to tinge a similar quantity of water with litmus to redden it, with two drops of test-sulphuric acid, and to compare the tint of this liquor with that of the solution of borax under examination. As the boracic acid contained in the hot solution of borax, and

which is deposited when the point of saturation is attained, interferes with the ready appreciation of the changes of colour, the solution should be allowed to cool before adding the last drops of acid. When the tinge produced in the borax liquor is exactly like that of the coloured water kept for comparison, the operator reads off the number of divisions of the test-acid employed, and then calculates therefrom the value of the borax assayed. The indication is a little too high, because it is necessary to pour a little excess of acid to produce a distinct reddening, and therefore it is customary to deduct three drops from the number indicated by the alkalimeter.

4. The number of divisions, we said, represents the quantity of real soda contained in the borax ; let us suppose, then, that 50 divisions have been required to decompose the 100 grains of borax analyzed ; since 100 divisions represent one equivalent or 32 of soda, it is evident that, in that case, only one half equivalent, or 16 of soda were present in the 100 grains of borax.

5. Now pure borax consists of—

1 equivalent of soda	.	NaO = 32
1 do. of boracic acid		BO ₃ = 70
10 do. of water	.	10 HO = 90
1 equivalent of borax	=	192

6. The operator may therefore easily calculate what quantity of borax corresponds to the 16 grains of soda found in the experiment :—

<i>Soda.</i>	<i>Borax.</i>	<i>Soda.</i>	<i>Borax.</i>
32	: 192	: 16	: $x = 96$

7. In the case above alluded to, therefore, the sample contains 96 per cent. of crystallized borax.

8. The adulterations of borax generally consist of *common salt* and of *alum*. These impurities may be easily detected ; the first, by solution of nitrate of silver, which will immediately produce a white curdy precipitate of chloride of silver,

insoluble in dilute acids, soluble in a slight excess of ammonia, and which may be separated by filtering, or by decantation after it has well settled. The presence of alum is recognized by the white bulky precipitate which ammonia produces when poured in the liquor, which precipitate is soluble in a solution of caustic potash. The adulteration of borax with alum is sometimes so considerable, that on adding ammonia, the whole solution stiffens into a thick jelly. When this is the case, the presence of alum may be readily detected, even by the taste, the alum having a styptic astringent, *slightly acid* flavour, whilst that of borax is sweetish and *slightly alkaline*; and the solution, if it contains alum, reddens the tincture of litmus, whilst that of borax, on the contrary, renders reddened litmus paper blue again. If the borax has been falsified with one tenth part of its weight of alum, it does not completely dissolve in water; that is to say, the liquor remains turbid, and a slight whitish sediment settles down in the glass.

BRANDY. GIN. RUM. WHISKY.

1. Brandy, gin, rum, &c., are alcoholic liquors, obtained from the distillation of certain fermented substances. Pure brandy is obtained from the distillation of wine, has a pungent, agreeable taste, barely recognizable, however, in the mixture of alcohol and water coloured with burnt sugar, flavoured with pepper, cayenne, or other acrid substances, to make believe in a strength of alcohol, the proportion of which is attenuated to the least possible amount.

2. The brandy made from raisins, corn, potato, kirschen, barley, and known under the names of gin, rum, whisky, &c., contain a small quantity of a peculiar oil to which they owe their respective flavour. All these liquors, however, are often adulterated to a great extent, the endeavour of the

maker being always to reduce the proportion of the alcohol, and to dissimulate its absence by the introduction of pungent or of acrid substances. This fraud may be easily detected by simply evaporating at a gentle heat a known quantity of the liquor to dryness, the acrid matter will then be left behind, and may be recognised by its flavour.

3. The principal and most esteemed brandies are the brandies of Cognac, Armagnac, Languedoc, Anjou, Bordeaux, Rochelle, Charenton, Orleans, Burgundy, and Champagne.

4. Brandy, when newly distilled, is white, but that met with in commerce is always of a yellowish, brown, or dark brown colour which is due to the presence of some extractive matter, and of tannic acid, which it has dissolved from the oak-casks in which it has been kept for a long time. But in order to simulate this colour of genuine brandy, the brandy of commerce is nothing else than new brandy or alcohol, at once converted apparently into old brandy by means of caramel, or burnt sugar.

5. Genuine French brandy has always an acid re-action upon test-paper, that is to say, it reddens blue litmus paper, because it always contains a small portion of vinegar, and when treated by a persalt of iron, it turns black, owing to the presence of tannic acid ; but new brandy, coloured by caramel, is not altered by a solution of persulphate of iron.

6. The proportion of alcohol contained in brandy may be determined by means of the hydrometer, or of the specific gravity bottle in the manner described in the article on *Alcohol*, or by distilling a portion of the sample and taking the specific gravity of the distilled portion. This must always be done when the brandy, being mixed with sugar or other matters, the operator wishes to ascertain the quantity of alcohol present. The specific gravity of genuine brandy is generally from 0.9695 to 0.9237.

7. In 1824, M. Gay Lussac invented an instrument called alcoholmeter (alcoomètre centésimal), on the principle of the

hydrometer. The instrument when immersed at 15° centigrades, (59° Fahrenheit) in a mixture of alcohol and water, indicates at once the quantity, in bulk, of alcohol present in the liquor. The alcoholmeter is divided into 100 degrees, and is so contrived that each degree represents one hundredth part of anhydrous or pure alcohol. Suppose, for example, that at the temperature of 15° centigrades (59° Fahr.), the alcoholmeter, being plunged in a sample of brandy at that temperature, sinks to the point marked 50°, it indicates that the brandy under examination consists of equal volumes of pure alcohol and of water. By means of such an instrument, therefore, the real quantity of alcohol contained in a given quantity of spirit, can immediately be determined by multiplying the volume by the number of degrees indicated by the immersion of the instrument, and dividing the product by 100. Thus, if a sample from a puncheon of brandy containing, for example, 135 gallons, being brought to 15° centigrade, indicates 50° of the alcoholmeter, the 135 gallons will therefore contain $67\frac{1}{2}$ gallons of pure alcohol.

$$135 \times 50 = 6750 \div 100 = 67.50,$$

or, which is the same thing—

$$135 \times 0.50 = 67.50.$$

8. Had the alcoholmeter indicated 45°, then the 135 gallons in the above example would have contained $60\frac{3}{4}$ gallons of pure alcohol.

$$135 \times 0.45 = 60.75 \quad (\text{See } Alcohol.)$$

9. Brandy contains sometimes a small quantity of *lead*, from the solder employed in the construction of stills; and of *copper*, from the still itself. *Acetate of lead* (sugar of lead) is occasionally, though rarely, added to brandy, for the purpose of facilitating the clarifying process. The brandy so treated may prove exceedingly injurious or even deadly, acetate of lead being a poison.

10. The presence of *copper* may be detected by filtering

a portion of the brandy through animal charcoal, in order to decolorize it ; ammonia is then to be poured into the clear liquor, to which it will impart a blue tinge, if copper be present, at least, in sufficient quantity. Several hours are sometimes requisite to determine the appearance of this colour. The presence of copper may also be detected by immersing at once a blade of perfectly clean iron in the brandy, and leaving it in for a few hours, when it will be found coated with a film of metallic copper. The brandy first decolorized by animal charcoal may also be tested for copper by a solution of ferrocyanuret of potassium (yellow prussiate of potash), which will then produce a brown precipitate, if copper be present.

11. The presence of *lead* is detected in brandy by means of dilute sulphuric acid, or of a solution of sulphate of soda, which will produce a white precipitate of sulphate of lead ; or better still, by passing a current of sulphuretted hydrogen, which will then produce a black precipitate of sulphuret of lead. The white precipitate produced by dilute sulphuric acid, or by solution of sulphate of soda, becomes black when moistened by hydrosulphuret of ammonia. If the quantity of the precipitate is large enough, it may be mixed with a little soda, and reduced before the blow-pipe upon charcoal. A bead of metallic lead may be thus obtained. (See the article on *Alcohol*.)

12. An instrument called *ebullioscope*, or *ebullition alcoholmeter*, has, within the last few years, been invented, by which the quantity of alcohol contained in brandy, wines, beer, and other spirituous liquors, can be easily ascertained in the course of a few minutes. The instrument is based upon the fact, that the boiling point of a spirituous liquid is scarcely altered by the presence, in moderate quantities, of the substances which may have been dissolved in it, and which, increasing the density of the liquid render ordinary alcoholmeters or hydrometers, useless for the purpose of indicating its alcoholic richness. The ebullioscope, as first invented by

M. Brossard-Vidal, modified by M. Conaty and by M. Lerebours, has been greatly improved by Dr. Ure, who published the following observations, which we reproduce here :—

“That the boiling temperature of water is increased by holding neutro-saline and saccharine substances in solution has been long known, and has been the subject of many experiments, made partly with the view of ascertaining from that temperature the proportion of the salt or sugar, and partly with the view of obtaining a practical liquid bath. But it seems to have been reserved for the Abbé Brossard-Vidal, of Toulon, to have discovered that the boiling temperature of alcoholic liquors is, in most cases, proportional to the quantity of alcohol, irrespectively of the quantity of neutro-saline or saccharine matter dissolved in them. When, however, such a quantity of dry carbonate of potash, or sugar, is added to a spirituous liquor as to abstract or fix in the solid state a portion of the water present, then the boiling temperature of that mixture will be lowered in proportion to the concentration of the alcohol, instead of being raised, as would be the case with water so mixed. But, generally speaking, it may be assumed as a fact, that the boiling point of an alcoholic liquor is not altered by a moderate addition of saline, saccharine, or extractive matter. On this principle M. Brossard-Vidal constructed an instrument for determining by that temperature the proportion of alcohol present. His chief object was to furnish the Revenue Boards of France with a means of estimating directly the proportion of alcohol in wines, so as to detect the too common practice of introducing brandy into their cities and towns under the mask of wine, and thereby committing a fraud upon the *octroi*.*

“M. Brossard-Vidal’s apparatus consists of a spirit-lamp, surmounted by a small boiler, into which a large cylindric glass bulb is plunged, having an upright stem of such calibre

* *Octroi* is the name of certain dues which are levied upon certain articles of consumption at their entry in towns, and the proceeds of which are applied to the various public wants of such towns.

that the quicksilver contained in them may, by its expansion and ascent when heated, raise before it a little glass float in the stem, which is connected by a thread with a similar glass bead, that hangs in the air. The thread passes round a pulley, which, turning with the motion of the beads, causes the index to move along a graduated circular scale. The numbers on this scale represent per centages of absolute alcohol, so that the number opposite to which the index stops, when the liquor in the cylinder over the lamp boils briskly, denotes the per centage of alcohol in it.

“M. Brossard-Vidal’s instrument was placed in my hands several months ago (Oct. 1847) by Mr. Field, who had obtained a patent in this country for determining thereby the strength of spirituous liquors. I made a great many experiments on the boiling points of alcohol at various successive degrees of watery dilution, and verified the general utility of the contrivance, but I found the construction of the instrument subject to several defects. The mass of mercury to be heated in the large bulb was so great as to occasion some loss of alcohol in the course of the experiment; the length of the thread was liable to be affected by the moisture of the air, it occasionally failed to move the pulley with sufficient delicacy on account of friction, and when the spirit in the lamp got heated in its case it flared up and burned the thread, thus rendering the apparatus useless till a fresh thread was experimentally adjusted to the beads.

“On these accounts I renounced the construction of M. Vidal, and adopted a more simple and direct form of indication.

“It consists, 1, of a flat spirit-lamp, which we will designate *A*, surrounded by a saucer for containing cold water to keep the lamp cool, should many experiments require to be made in succession; 2, of a boiler, which we will designate *B*, and which fits by its bottom cage (*C*) upon the case of the lamp. A damper-plate is used for modifying the flame of the lamp, or extinguishing it when the experiment is completed.

A thermometer, which we will designate *D*, made with a very minute bore, in the manner of the Rev. Mr. Wollaston's instrument for measuring the height of a mountain by the boiling point of water on its summit, is placed in the boiler. The bottom of the scale in this thermometer is marked *P* for proof on the left side, and 100 (of proof spirit) on the right side. It corresponds to 178.6 Fahr. very nearly, or the boiling point of alcohol of 0.920, specific gravity. The following table gives the boiling points corresponding to the indicated densities :—

Temp. Fahr.	Specific gravity.
178.6	0.9200..P.
179.75	0.9321..10 U. P.
180.4	0.9420..20 „
182.00	0.9516..30 „
183.40	0.960 ..40 „
185.6	0.9665..50 „
189.0	0.9729..60 „
191.80	0.9786..70 „
196.4	0.9850..80 „
202.0	0.992 ..90 „

“The above table is the mean of a great many experiments. When alcohol is stronger than 0.92, or the excise-proof, its boiling point varies too little with its progressive increase of strength to render that test applicable in practice. In fact, even for proof spirits, or spirits approaching in strength to proof, a more exact indication may be obtained by diluting them with their own bulk of water before ascertaining their strength, and then doubling it.

“The boiling point of any alcoholic liquor is apt to rise if the heat be long continued, and thereby to lead into error in using this instrument. This source of fallacy may be in a great measure avoided by adding to the liquor in the little boiler about a teaspoonful (thirty-five grains) of common culinary salt, which has the curious effect of arresting the mercury in the thermometer at the true boiling point of

the spirit, wine, or beer, to enable a correct reading to be had.

“The thermometer is at first adjusted to an atmospheric pressure of 29.5 inches. When that pressure is higher or lower, both water and alcohol boil at a somewhat higher or lower temperature. In order to correct the error, which would hence arise in the indications of this instrument under different states of the weather, a barometrical equation is attached to the thermometer by means of the subsidiary scale.

“Having stated the principles and the construction of the ebullition alcoholmeter, I shall now describe the mode of its application.

“1st. Light the spirit-lamp *A*.

“2nd. Charge the boiling vessel *B* with the liquid to be tested (to within an inch of the top), introducing at the same time a paper of the powder; then place the vessel *B* (the damper-plate being withdrawn) on to the lamp *A*.

“3rd. Fix the thermometer *D* on the stem attached to *B*, with its bulb immersed in the liquid. The process will then be in operation.

“The barometrical scale indicated on the thermometer is opposite the mean boiling point of water. Prior to commencing operations for the day, charge the boiler *B* with water only, and fix the instrument as directed; when the water boils freely the mercury will become stationary in the stem of the thermometer, opposite to the true barometrical indication at the time. Should the mercury stand at the line 29.5, this will be the height of the barometer, and no correction will be required; but should it stand at any other line, above or below, then the various boiling points will bear reference to that boiling point.

“In testing spirituous or fermented liquors of any kind, when the mercury begins to rise out of the bulb of the thermometer into the stem, push the damper-plate half-way in its grove to moderate the heat of the flame. When the liquor boils freely, the mercury will become stationary in the

stem; and opposite to its indication, on the left, the under-proof per centage of spirit may be read off at once, if the barometer stand that day at 29.5 inches; while on the right hand scale the per centage of proof spirit is shown; being the difference of the former number from 100. The damper-plate is to be immediately pushed home, to extinguish the flame.

27. "The alcoholmeter will by itself only indicate the per centage of alcohol contained in any wine, but by the aid of the hydrometer the proportionate quantity of saccharum in all wines may be readily and easily determined. In testing a sample of wine, first take the specific gravity, and suppose it to be 989, then charge the boiler of the alcoholmeter with the wine, as directed, and at the boiling point it indicates the presence of alcohol at 69.6 per cent.^{up}, whose specific gravity will be found to be 979; deduct that gravity from the gravity of the bulk, or 989, and 10 will remain, which 10 degrees of gravity, upon reference to the wine table, will be found to represent 25 lbs. of saccharine or extractive matter in every 100 gallons, combined with $30\frac{4}{10}$ gallons of proof spirit.

28. "Sikes's hydrometer will only show the specific gravity of liquids lighter than water (or 1000), and for wines in general use, their gravities being lighter than that article, will answer every purpose; but there are wines whose gravities are heavier than water, such as Mountain, Tent, rich Malagas, Lachrymæ Christi, &c., to embrace which additional weights to the hydrometer will be required, as for cordialized spirits, &c. In testing a sample of rich Mountain, its s.g. was found to be 1039, or 39 degrees heavier than water; that wine at the boiling point indicated the alcohol at 72.5 per cent.^{up}; but 980 s.g. deducted from 1039 leaves 59 degrees of s.g.; against 59 of the wine tables will be found 147.5 or $147\frac{1}{2}$ lbs. of saccharine or extractive matter combined with $27\frac{1}{2}$ gallons of proof spirit to every 100 gallons.

29. "Should the barometer for the day show any other indication above or below the standard of 29.5, the thermometer scale will then only show the apparent strength, and

reference must be had to the small ivory indicator *E*, it being the counterpart of the barometrical scale of the thermometer, thus—should the barometer indicate 30, place 30 of the indicator against the boiling point of the liquid, and opposite the line 29.5 will be found the true strength.

“*Example 1.*—Barometer at 30.—Suppose the mercury to stop at the boiling point 72-^{up}, place 30 of the indicator against 72 on the thermometer, and the line of 29.5 will cut 69.6-^{up}, the true strength.

“*Example 2.*—Barometer at 29.—Suppose the mercury to stop at the same point, 72-^{up}, place 29 of the indicator against 72 on the thermometer, and the line of 29.5 will cut 74.3-^{up}, the true strength.

FOR MALTED LIQUORS.

“To all brewers and dealers in fermented liquors this principle, by its application, will supply a great desideratum, as it will not only show the alcohol created in the wort by the attenuation, as well as the original weight of the wort prior to fermentation, but it will indicate the value of malt liquors in relation to their component parts. It will likewise be a ready means of testing the relative value of worts from sugar compared with grain, as well as being a guide to the condition of stock beers and ales.

“To ascertain the strength of malt liquors and their respective values, the instrument has been supplied with a glass saccharometer, testing-glass, and slide-rule. Commence by charging the testing-glass with the liquid, then insert the saccharometer, to ascertain its present gravity or density per barrel, and at whatever number it floats, that will indicate the number of pounds per barrel heavier than water.

“*Example 1.*—Suppose the saccharometer to float at the figure 8, that would indicate 8lbs. per barrel; then submit the liquid to the boiling test, with the salt as before directed, and suppose it should show (the barometrical differences being accounted for) 90-^{up}, that would be equivalent

to 10 per cent. of proof alcohol. Refer to the slide-rule, and place *A* on the slide against 10 on the upper line of figures, and facing *B* on the lower line will be 18, thus showing that 18lbs. per barrel have been decomposed to constitute that per centage of spirit ; then, by adding the 18lbs. to the present 8lbs. per barrel, the result will be 26lbs., the original weight of the wort after leaving the copper.

“ *Example 2.*—The saccharometer marks 10lbs. per barrel, and at the boiling point it indicates 88^{up}, equivalent to 12 gallons of proof spirit per cent. ; place *A* against 12, and opposite *B* will be $21\frac{1}{2}$ lbs. per barrel, when, by adding that to the 10lbs. present, $31\frac{1}{2}$ lbs. will be the result.

TO ASCERTAIN THE RELATIVE VALUE.

“ Suppose the price of the 26lbs. beer to be 36s. per barrel, and the $31\frac{1}{2}$ lbs. beer to be 40s. per barrel, to ascertain which beer will be the cheapest, place 26 on the opposite side of the rule against 36, and opposite $31\frac{1}{2}$ lbs. will be 43s. 7d. showing that the latter beer is the cheapest by 3s. 7d. per barrel.

“ By taking an account of the malt liquors by this instrument prior to stocking, it may be ascertained at any time whether any alteration has taken place in their condition, either by an increase of spirit by after fermentation and consequent loss of saccharum, or whether, by an apparent loss of both, acetous fermentation has not been going on towards the ultimate loss of the whole.

“ This instrument will likewise truly indicate the quantity of spirit per cent. created in ‘distillers’ worts, whether in process of fermentation or ready for the still : the only difference will be in the allowances on the slide-rule.

“ N.B.—The saccharometers applicable to the foregoing rules for beers, ales, &c., have been adjusted at the temperature 60 Fahrenheit, and will be found correct for general purposes, but where extreme minuteness is required,

the variation of temperature must be taken into account ; therefore, for every 10 degrees of temperature above 60, 3-10ths of a pound must be added to the gross amount found by the slide-rule ; on the contrary, for every 10 degrees below 60, 3-10ths of a pound must be deducted.

FOR CORDIALIZED SPIRITS.

“The operation in this instance is somewhat different from that of beers, which have the alcohol created in the original worts ; whereas, in cordialized spirits, gins, &c., the alcohol is the original, and the saccharine matter, or sugar, is an addendum.

“If 100 gallons of spirit are required at a given strength, say 50 per cent. under proof, 50 gallons of proof spirit, with the addition of 50 gallons of water, would effect that object, and upon testing it by the alcoholmeter, it would be found as correct as by the hydrometer. But in cordializing spirits it is different, for to the 50 gallons of proof spirit 50 gallons of sugar and water would be added, thereby rendering the hydrometer useless, except for taking the specific gravity of the bulk, and, according to the quantity of sugar present, so a relative quantity of water must have been displaced ; and as the sugar has no reducing properties, the alcoholmeter will only show the strength of the cordial in relation to the water contained in it, as the principle indicates, irrespectively of saccharine or extractive matter present.

“Suppose, in making 100 gallons of cordial at 50^{up}, 3lbs. of sugar are put to the gallon, or 300lbs. to the 100 gallons, that 300lbs. displacing $18\frac{67}{100}$ gallons of water, only $31\frac{33}{100}$ gallons of water instead of 50 having been applied ; the sugar, without reducing properties, making up the bulk of 100 gallons, which is meant to represent 50 per cent. ^{up}.

“The alcoholmeter will only show at the full point of ebullition the alcoholic strength in relation to the water in the 100 gallons of the mixture, or 35 per cent. ^{up}, leaving 15 per cent. to be accounted for on the bulk.

“As the quantity of sugar present must be determined before that per centage can be arrived at, a double object will be effected by so doing, namely, eliciting in all instances the quantity of sugar present, as well as the per centage of spirit to be accounted for.

“*Example 1.*—In taking the s. g. of a cordial, suppose it to be found 1076, then submit the liquid to the boiling point, and having ascertained the per centage of alcohol, and it proves to be 35^{up}, the s. g. of alcohol at that strength will be found to be 956 ; deduct 956 from the s. g. of the bulk, or 1076, and 120 will remain ; refer that to its amount on the head line of Table No. II. namely 120, under which will be found 3, representing 3lbs. of sugar to the gallon ; and by running the eye down its column to opposite the alcoholic strength indicated (35^{up}) will be found 14.9, which represents the per centage of water displaced by the sugar, and which amount of 14.9, added to the 35 per cent. ascertained, makes the total upon the bulk 49.9 per cent.^{up}, with 3lbs. of sugar to the gallon.

FOR GINS, ETC.

“*Example 3.*—In taking the s. g., suppose it be found 957 ; then submit to the boiling point, and it proves to be 14^{up}, whose s. g. is 937, which, deducted from 957, leaves s. g. 20 ; on the head line of Table No. II., under 20, will be found $\frac{1}{2}$, or $\frac{1}{2}$ lb. of sugar to the gallon ; and on running the eye down to the opposite 14^{up} will be found 3.0, which added to the 14, makes the total on the bulk 17 per cent.^{up}, with 50lbs. of sugar to the 100 gallons.

“To chemists for their tinctures, &c., this instrument will be found essentially useful.

“N.B.—Care must be taken that the mercury is entirely in the bulb of the thermometer before it is fixed on the stem for operation, and in all cases (except for water) the salt must be used.

CONCLUSION.

“Wines are peculiarly subject to be mystified by ad-

alterations of various kinds. It will prove of great advantage to the public when the relative quantity of fruit, or saccharum, and alcohol requisite to constitute the normal wine of each species is well ascertained.

“Some beers possess a remarkable narcotic power, by which they cause drowsiness and stupor without corresponding previous exhilaration. Such beverages may justly be suspected of having been sophisticated with *cocculus Indicus*, opium, or some analogous drug; and this suspicion may become certainty if they be shown by the alcoholmeter to contain only a few per cents. of fermented spirit.

No. I.—TABLE OF SPECIFIC GRAVITIES, by Sikes's Hydrometer, adapted to Field's Patent Alcoholmeter for Cordialized Spirits.

TEMPERATURE 60°. SPECIFIC GRAVITY OF WATER 1000°.

60		80		100		120		140		160		180	
Wt.	S. G.	Wt.	S. G.	Wt.	S. G.	Wt.	S. G.	Wt.	S. G.	Wt.	S.	Wt.	S. G.
60	922	80	961	100	1000	120	1041	140	1085	160	1129	180	1175
1	924	1	963	1	1002	1	1044	1	1087	1	1131	1	1178
2	926	2	965	2	1004	2	1046	2	1089	2	1134	2	1180
3	928	3	967	3	1006	3	1048	3	1091	3	1136	3	1182
4	930	4	969	4	1008	4	1050	4	1093	4	1139	4	1185
5	932	5	971	5	1010	5	1052	5	1096	5	1141	5	1187
6	934	6	973	6	1012	6	1054	6	1098	6	1143	6	1189
7	936	7	975	7	1014	7	1056	7	1100	7	1145	7	1191
8	938	8	977	8	1016	8	1058	8	1102	8	1148	8	1194
9	940	9	979	9	1018	9	1061	9	1104	9	1150	9	1196
70	942	90	981	110	1020	130	1062	150	1107	170	1152	190	1199
1	943	1	983	1	1022	1	1065	1	1109	1	1155		
2	945	2	985	2	1024	2	1067	2	1111	2	1157		
3	947	3	987	3	1026	3	1069	3	1113	3	1159		
4	949	4	989	4	1029	4	1071	4	1116	4	1162		
5	951	5	991	5	1031	5	1074	5	1118	5	1164		
6	953	6	993	6	1033	6	1076	6	1120	6	1166		
7	955	7	995	7	1035	7	1078	7	1123	7	1168		
8	957	8	997	8	1037	8	1080	8	1125	8	1171		
9	959	9	999	9	1039	9	1082	9	1127	9	1173		
80	961	100	1000	120	1041	140	1085	160	1129	180	1175		

“The foregoing table, which shows the specific gravity on the bulk of the mixture, bears reference to the table (No. II.) of the alcoholmeter following.

No. II.—TABLE showing the lbs. of Sugar per gallon in Cordialized Spirits, with the per Centages to be added to the indicated Strength, per the Alcoholmeter.

Difference of Gravity.		10	15	20	25	30	35	40	45	50	Difference of Gravity.	
lbs. of Sugar per Gallon.		4 oz. or 25 to 100	6 oz. 37½ to 100	8 oz. 50 to 100	10 oz. 62½ to 100	12 oz. 75 to 100	14 oz. 87½ to 100	1.0	1.2	1.4	lbs. of Sugar per Gallon.	
Sp. Grav. of Spirit.	Per Cent. of Spirit.										Per Cent. of Spirit.	Sp. Grav. of Spirit.
920	Pf.	1.6	2.5	3.4	4.4	5.3	6.2	7.1	8.1	9.0	Pf.	920
923	2.5	1.6	2.5	3.3	4.3	5.2	6.1	6.9	7.8	8.8	2.5	923
926	5.	1.5	2.4	3.2	4.2	5.0	5.9	6.8	7.7	8.6	5.	926
929	7.5	1.5	2.3	3.2	4.1	4.9	5.8	6.6	7.5	8.4	7.5	929
932	10.	1.4	2.2	3.1	4.0	4.8	5.7	6.5	7.4	8.2	10.	932
935	12.5	1.4	2.2	3.1	3.9	4.7	5.5	6.3	7.2	8.0	12.5	935
938	15.	1.4	2.1	3.0	3.8	4.6	5.4	6.2	7.0	7.8	15.	938
940	17.5	1.3	2.1	2.9	3.7	4.5	5.3	6.0	6.8	7.6	17.5	940
943	20.	1.3	2.0	2.8	3.6	4.4	5.2	5.9	6.7	7.5	20.	943
945	22.5	1.3	2.0	2.7	3.5	4.3	5.0	5.7	6.5	7.3	22.5	945
948	25.	1.2	1.9	2.6	3.4	4.1	4.8	5.5	6.3	7.0	25.	948
950	27.5	1.2	1.9	2.5	3.3	4.0	4.7	5.3	6.1	6.8	27.5	950
952	30.	1.1	1.8	2.4	3.1	3.8	4.5	5.1	5.8	6.5	30.	952
954	32.5	1.1	1.7	2.3	3.0	3.6	4.3	4.8	5.5	6.2	32.5	954
956	35.	1.0	1.6	2.2	2.9	3.5	4.1	4.6	5.3	6.0	35.	956
958	37.5	1.0	1.6	2.1	2.8	3.4	3.9	4.4	5.1	5.8	37.5	958
960	40.	.9	1.5	2.0	2.7	3.2	3.8	4.3	4.9	5.5	40.	960
962	42.5	.9	1.5	2.0	2.6	3.1	3.6	4.1	4.7	5.3	42.5	962
964	45.	.9	1.4	1.9	2.5	3.0	3.5	4.0	4.6	5.1	45.	964
965	47.5	.8	1.4	1.9	2.4	2.9	3.4	3.9	4.4	4.9	47.5	965
967	50.	.8	1.3	1.8	2.3	2.8	3.3	3.8	4.3	4.8	50.	967
969	52.5	.7	1.2	1.7	2.2	2.6	3.1	3.6	4.1	4.5	52.5	969
970	55.	.7	1.2	1.6	2.0	2.4	2.9	3.4	3.8	4.2	55.	970
972	57.5	.6	1.1	1.5	1.9	2.2	2.7	3.1	3.5	3.9	57.5	972
973	60.	.6	1.0	1.4	1.8	2.1	2.5	2.9	3.3	3.6	60.	973
974	62.5	.6	1.0	1.3	1.7	2.0	2.4	2.7	3.1	3.5	62.5	974
976	65.	.5	.9	1.2	1.5	1.8	2.2	2.5	2.8	3.1	65.	976
977	67.5	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	2.9	67.5	977
979	70.	.4	.7	1.0	1.3	1.5	1.8	2.1	2.4	2.6	70.	979
980	72.5	.4	.7	.9	1.1	1.3	1.6	1.9	2.1	2.3	72.5	980
982	75.	.3	.6	.8	1.0	1.2	1.4	1.6	1.8	2.0	75.	982
983	77.5	.3	.5	.7	.9	1.0	1.2	1.4	1.6	1.8	77.5	983
984	80.	.2	.4	.6	.8	.9	1.0	1.2	1.4	1.6	80.	984
986	82.5	.2	.3	.5	.7	.8	.9	1.0	1.2	1.4	82.5	986
988	85.	.2	.2	.4	.6	.7	.8	.9	1.0	1.2	85.	988
990	87.5	.1	.2	.3	.5	.6	.7	.8	.9	1.0	87.5	990
992	90.	.1	.1	.2	.4	.5	.6	.7	.8	.9	90.	992
994	92.5	..	.1	.2	.3	.4	.5	.6	.7	.8	92.5	994
996	95.	..	..	.1	.2	.3	.4	.5	.6	.7	95.	996
998	97.5	..	..	..	.1	.2	.3	.4	.5	.6	97.5	998

“ The instrument in its complete state is made and sold by Mr. Joseph Long, Little Tower Street. The tables, of which

the above is only a portion, and the barometric indicator, have been constructed by him and Mr. Atlee."

13. In 1830, M. Tabarié invented an instrument called *Æno-metre*, for the determination of the quantity of alcohol contained in wine and other spirituous liquids. The process consisted in boiling a determined quantity of the liquid under examination in an open vessel, allowing the alcohol freely to escape in the air. The evaporation was then made up by adding a corresponding quantity of water, and the quantity of alcohol was estimated from the difference of the specific gravity of the liquid before and after the experiment. Whether this method gives sufficiently accurate and uniform results, however, has not yet been satisfactorily ascertained, but its extreme simplicity recommends it to the attention of chemists.

BRASS.

DUTCH GOLD. CRYSOCAL. SIMILOR. PRINCE RUPERT'S METAL. PINCHBECK. MANNHEIM GOLD.

1. Brass is one of the most important alloys ; it consists chiefly of copper and of zinc, in various proportions, according to the use for which it is intended. Besides copper and zinc, brass contains often a certain proportion of tin and of lead. We give here the result of the analysis of several kinds of this alloy.

	Similor,				Ham- mering	Cryso- cal.	Wire.		Fine Casting.		For Gilding.			For Turning.		
Copper.	80	84	86	88	70	92	66.5	64.2	91.2	91.7	63.7	82	64.45	61.6	65.8	64.2
Zinc.	20	16	14	12	30	6	33.1	33.1	5.6	5.0	33.6	18	32.44	35.3	31.8	32.8
Tin.	"	"	"	"	"	6	"	"	1.4	2.8	0.2	3	0.25	0.2	0.2	0.4
Lead.	"	"	"	"	"	"	0.4	0.8	1.8	2.5	2.5	1	2.86	2.9	2.2	2.0
	100	100	100	100	100	104	100.0	91.1	100.0	100.0	100.0	104	100.0	100.0	100.0	109.4

2. The *analysis of brass* is performed as follows :—

3. Take 100 grains of the alloy and dissolve them in nitric acid which will leave the tin in an insoluble state as peroxyde of tin, which may be collected on a filter. The liquor filtered

therefrom should then be evaporated to a small bulk, and whilst the evaporation is going on sulphuric acid is added, the concentrated solution is to be diluted with water, and a certain quantity of alcohol is poured in. This produces a precipitate of sulphate of lead which should be allowed to settle well by leaving the liquor at rest for some time, after which it may be collected on a filter, washed with water to which alcohol has been added, and after carefully scraping it from the filter it is ignited in a porcelain crucible. The filter should be burnt on the cover of the crucible, and the ashes added to the ignited mass. The liquor filtered from the precipitated sulphate of lead is then treated by sulphuretted hydrogen, in order to precipitate the copper in the state of sulphuret of copper (black), which should be collected at once on a filter, and washed thereon, without interruption, with water containing some sulphuretted hydrogen, and then dried. The black sulphuret of copper is now to be transferred to a glass-beaker, the filter is burnt and the cover of a porcelain crucible; the ashes are added to the mass in the glass-beaker, and pure nitric acid is poured upon the whole, which is left to digest until the separated sulphur has acquired the characteristic yellow colour; it is then separated by filtering, the filtered liquor is diluted with water and precipitated by potash. The whole liquor containing the precipitate should then be boiled, by which operation the precipitated protoxyde of copper becomes brown or black; it should then be collected on a filter, washed with hot water, dried, ignited, and weighed immediately after cooling in the platinum crucible in which it has been ignited, and which should be kept well closed in order to avoid the absorption of moisture.

4. The zinc may now be separated from the solution which was filtered from the precipitated sulphuret of copper, by first heating the said filtered liquor, in order completely to expel the sulphuretted hydrogen, (for which purpose the solution should be heated until all odour of the gas has disappeared,)

a solution of carbonate of soda is then poured gradually into it, stirring all the while, until a white precipitate of carbonate of zinc is no longer produced, or until the solution shows a strongly alkaline re-action upon turmeric paper; the whole is then boiled for a few minutes; the carbonate of zinc produced by the carbonate of soda is collected on a filter, washed with hot water, dried, and ignited, in order to convert it into oxyde of zinc, in which state it is weighed.

74	grains of peroxyde of tin = 58 of tin.
152	do. of sulphate of lead = 104 of lead.
40	do. of protoxyde of copper = 32 of copper.
40	do. of oxyde of zinc = 32 of zinc.

B R E A D.

1. The substances which are employed for adulterating this most important of all articles of food, besides those which are enumerated in the article on *Flour*, are the following :—

Alum.	Chalk.
Subcarbonate of magnesia.	Plaster.
Sulphate of copper.	Lime.
Sulphate of zinc.	Clay.
Subcarbonate of ammonia.	Starch.
Carbonate of potash.	Water.
Bicarbonate of potash.	Pulp of potatoes.

2. The introduction of *alum* in bread appears to be a practice of long-standing; it enables the baker to give to bread made of flour of an inferior quality the whiteness of the best bread, and to add potato-flour, ground beans and peas, to a certain extent, to wheat flour, without materially altering the appearance of the bread. The use of alum by bakers is almost universal in this metropolis; at any rate, I have

invariably found distinct evidence of the presence of this material in the bread which I obtained from various bakers, some of which are esteemed of the highest *respectability*.

3. The quantity of alum in bread varies however according to the quality of the flour employed, and it appears to act somewhat in the same manner as sulphate of copper, that is to say, it enables the baker to make bread with flour of inferior quality with less labour, and to introduce therein, a greater quantity of water, by which the yield is increased. In order to obtain these results, however, a much larger proportion of alum than of the salt of copper is required, since, in fact, no appreciable effect is produced, when the proportion of alum is less than $\frac{1}{908}$, while with the salt of copper $\frac{1}{15000}$ is sufficient. Hence, although alum is of course very far from being so dangerous as the salts of copper, yet the constant ingestion of that matter, day after day, may prove a source of disease, especially with persons of weak constitutions, or of a bilious or costive habit; sometimes it creates a painful sensation in the stomach, and may even induce nausea, vomiting, gripe, &c.

4. The process recommended by M. Kuhlman for the detection of alum in bread, consists in incinerating about 3000 grains of bread, porphyriizing the ashes so obtained, treating them by nitric acid, evaporating the mixture to dryness, and diluting the residuum with about 300 grains of water, with the help of a gentle heat; without filtering, a solution of caustic potash is then added, the whole is boiled a little, filtered, the filtrate is tested with a solution of sal ammoniac, and boiled for a few minutes. If a precipitate is formed, it is alumina, which may be collected on a filter, washed, perfectly dried, carefully ignited in a platinum crucible, and then weighed. 50 grains of alumina represent 332 of crystals of alum.

5. *Another process*, indicated by Messrs. Robine and Parisot, consists in crumbling down about 2000 grains of the

bread under examination, which should be somewhat stale or dried, in order that it may be more easily crumbled. The mass should be macerated in cold water for two or three hours, and then squeezed through a clean piece of white linen. The liquor thus obtained should now be filtered, and the filtrate being placed in a porcelain capsule, should be evaporated to dryness at a steam heat. The residuum being now treated by a small quantity of water and filtered, the operator divides the filtrate into two portions.

6. If aqueous ammonia, or a solution of sal ammoniac, being poured into one of these portions, and solution of chloride of barium in the other portion, produce in each of them a white precipitate, it is a sign of the presence of alum. That produced by ammonia, more especially, is conclusive.

7. The experiment should be performed in the way indicated ; for if the operator were merely to filter the liquor squeezed from the linen and at once add solution of chloride of barium thereto, a precipitate or milkiness would be produced, which might be mistaken for sulphate of baryta, but which would be coagulated vegetable albumen, &c. The filtrate should therefore be first boiled or evaporated to dryness, and the dry mass being digested in water and filtered, may then be examined, as was said ; or the liquor squeezed from the linen may be at once boiled, then filtered, and the filtrate may next be treated by ammonia and by chloride of barium, taking care to concentrate the filtrate, if too bulky, before testing ; but the proportion of alum is generally large enough to become readily perceptible in the unconcentrated filtrate when tested by ammonia, which produces a white flaky precipitate, as we said.

DETECTION OF COPPER.

8. The origin of the use of sulphate of copper in bread is unknown, and fortunately this dangerous falsification has, I

believe, never been resorted to in this country. By the addition of a small quantity of sulphate of copper to flour, bread may be made of meal of inferior quality with less labour, and a larger quantity of water may be introduced into it. Sulphate of copper, according to Dumas, exercises a very powerful action upon the fermentation of the dough, even when so small a quantity as $\frac{1}{70000}$ of sulphate is introduced, which quantity represents only one part of metallic copper for 3000 parts of bread. The greatest effect is produced by $\frac{1}{30000}$ or $\frac{1}{15000}$ of sulphate ; but any quantity beyond this changes the colour of the loaf, which acquires at the same time a peculiar and disagreeable odour resembling that of leaven.

9. When a loaf contains more than $\frac{1}{4000}$ of sulphate, it becomes aqueous, and full of large eyes ; and if the proportion exceed $\frac{1}{1800}$ the dough will not rise, the fermentation altogether stops, the bread then assumes a green colour, and acquires a sour and disagreeable smell.

10. Since in order to obtain the desired effect, the quantity of sulphate of copper must be very small, and not amount to more than $6\frac{1}{4}$ grains per 100lbs. of bread, the bread so treated might be eaten with impunity perhaps, or at least without immediate danger by persons in good health ; but when we consider the very irritating action of sulphate of copper on the gastro-intestinal membrane, it is hardly possible that disease be not ultimately induced by the daily consumption of that dangerous poison, even in the small proportion above related, not to speak of the possibility of an over-dose being introduced into the bread through carelessness, ignorance, or mistake.

11. Fortunately the detection of copper in bread may be very easily effected. Even so trifling a quantity as one part of sulphate of copper in 9000 parts of bread may be summarily discovered in white bread, by moistening the latter with solution of ferrocyanuret of potassium ; the bread so treated immediately assumes a pink tinge if any salt of copper be present.

12. But for the purpose of determining the quantity of the salt of copper, another process, indicated by Kulhman, must be resorted to, by which one part of sulphate of copper in 70,000 parts of bread can be estimated.

13. The operator weighs 3000 grains of the bread which is suspected of being poisoned by a salt of copper, and incinerates them completely in a shallow platinum capsule. The incinerated mass should then be reduced to impalpable powder in an agate mortar, mixed in a porcelain capsule with about one quarter of an ounce of nitric acid, and heated until all the acid has evaporated and a clammy mass only is left, which should be digested with about 300 grains of pure distilled water, with the help of heat. The liquor should then be filtered, in order to separate the portions which have resisted the action of the acid. A slight excess of ammonia, and a few drops of subcarbonate of ammonia, are then added to the filtrate. The bulky precipitate which this addition may have produced should be separated by filtering. The liquor filtered therefrom should next be boiled for a few minutes, in order to expel the excess of ammonia and reduce it to about one fourth of its bulk, after which it should be acidified with a drop of nitric acid, and divided into two portions, to one of which, ferrocyanuret of potassium, and to the other, sulphuretted hydrogen, or hydrosulphuret of ammonia are to be added. If even so small a quantity as $\frac{1}{70000}$ of copper is present, the solution tested with ferrocyanide of potassium will assume a pink tinge, and after a few hours, a slight crimson precipitate will appear. The other portion tested with sulphuretted hydrogen, or with hydrosulphuret of ammonia, will, under the same circumstances, turn brownish, and, after standing for a few hours, a slight brown or black precipitate will be deposited.

14. Another process, indicated by Messrs. Robine and Parisot, and by which $\frac{1}{83300}$ of copper may be detected, consists in macerating a certain quantity of the suspected bread (for example 2000 grains) in water, until it is reduced to a

pappy consistence, in which state it is then put into a porcelain capsule, sulphuric acid being at the same time added to it in sufficient quantity to render the mass strongly acid. A piece of iron wire, perfectly bright and clean, should now be immersed into the pappy mass, prepared as above directed, and left therein for about a day or two. At the end of that time it will be found, on withdrawing the iron wire, that it is coated with copper, more or less visibly, according to the quantity of copper contained in the bread. If only a very minute quantity of copper was contained in the bread, the copper will be found to have deposited on the iron, *principally at the top*, that is to say, immediately under the level of the paste covering the iron.

ADULTERATION BY CARBONATE OF MAGNESIA.

15. From the experiments of M. E. Davy it would appear, that the addition of carbonate of magnesia to flour of inferior quality, in the proportion of 25 or 30 grains of carbonate per pound weight of flour, somewhat augments the quantity of the bread manufactured with such flour. The admixture of carbonate of magnesia in such proportions can hardly be considered unwholesome; but the dose often exceeds that quantity to a very considerable degree, and so much the more easily, that carbonate of magnesia strongly resembles flour in appearance.

16. The influence of carbonate of magnesia upon the rising of the dough, however, is inconsiderable, so that the increase of weight is quite a secondary consideration; its chief use is for the purpose of counteracting the dark colour which certain species of meal of inferior quality give to the bread manufactured therefrom, carbonate of magnesia having the property of imparting a yellowish colour to bread when in the proportion of $\frac{1}{42}$.

17. The process usually resorted to for the detection of carbonate of magnesia in bread, consists in macerating the

crumb in distilled water, slightly acidified with sulphuric or with muriatic acid, and gently squeezing the mass through a piece of clean linen. The liquor is then treated by carbonate of potash, which will, *especially by boiling*, produce a white precipitate of carbonate of magnesia, if this salt be present.

18. Although, as we said, this is the process usually adopted, it cannot be much relied upon, because *pure bread* when so treated, always yields a white precipitate, and moreover, unless several precautions be observed, may be the cause of serious errors. Solution of pure potash might be employed instead of that of the carbonate of that base, but the precipitate would then consist of pure magnesia which is more soluble in water than carbonate of magnesia.

19. It is better therefore to employ Messrs. Robine and Parisot's method, by which even $\frac{1}{5000}$ of carbonate of magnesia may be detected. It is as follows:—

20. Take 2000 grains of the bread to be examined, crumble it, and pour upon it a quantity of distilled water sufficient to cover the bread, and let the whole macerate for two or three hours. The pappy mass should then be gently squeezed in a piece of linen, so as to express the liquid portion, and after adding acetic acid it is to be evaporated to dryness in a porcelain capsule in the sand bath, that the residuum may not be decomposed; the capsule is then withdrawn and allowed to cool. The residuum is now to be treated by a certain quantity of alcohol, and stirred. The alcohol dissolves only the acetate of magnesia (into which the carbonate of magnesia has been transformed), the liquor is then filtered and evaporated to dryness. The dry residuum should be redissolved in a small quantity of water, filtered again, if necessary; and carbonate of potash being added, will now produce a precipitate of carbonate of magnesia insoluble in an excess of the precipitant.

21. The quantity of carbonate of magnesia contained in the 2000 grains of bread may be determined by macerating the latter, pulverizing the ashes, and pouring acetic acid upon

them. The whole is then evaporated to dryness in order to expel the excess of free acid, the dry residuum is next treated by alcohol and filtered. The filtrate is now evaporated to dryness, the residuum is redissolved in a small quantity of water, and the solution thus obtained is precipitated by carbonate of potash, added in slight excess, and boiled; the magnesia, if present, falling down as carbonate of magnesia, should be collected on a filter washed with hot water, dried, ignited, and weighed. The precipitate after ignition consists of pure magnesia, provided the ignition be continued until the mass no longer diminishes in weight; 20 grains of magnesia represent 42 of carbonate of magnesia.

ADULTERATION BY SULPHATE OF ZINC.

22. According to Kuhlman it would appear, that sulphate of zinc acts like sulphate of copper, but is less effective. Sulphate of zinc is far from being so virulent a poison as sulphate of copper, but is, nevertheless, a dangerous substance, the presence of which may be detected in bread as follows:—

23. Take about 2000 grains of the suspected bread, crumble, and digest them for two or three hours in distilled water, and then squeeze the liquid portion gently through a clean piece of linen; filter, evaporate to dryness by means of the sand bath, and redissolve the dry residuum in water; add an excess of ammonia to the solution, filter again if necessary, and to the strongly ammoniacal and clear liquor thus obtained, if the further addition of hydrosulphuret of ammonia produces a white, bulky precipitate, it is sulphuret of zinc, from which the quantity of zinc may be estimated exactly as is described in the article on *Zinc*. (See *Calamine* and *Blende*.)

ADULTERATION BY PLASTER, CLAY, BONE DUST, ETC.

24. Plaster, clay, bone dust, chalk, and other similar substances are sometimes, though rarely, employed to augment

the weight of bread; considering, however, that unless they be introduced in large quantity, the admixture would hardly prove remunerative, the fraud may most readily be detected, and its extent ascertained, by incinerating a given quantity of the suspected bread, and weighing the ashes. If the bread be pure, 2000 grains should not leave more than from 15 to 25 grains of ashes; if more considerable, foreign substances are present, and the ashes should then be examined as was described for the detection of alum and of lime. Bread made with flour containing more than four per cent. of chalk, is spotted here and there with white marks which are agglomerations of carbonate of lime.

ADULTERATION BY FECULA, OR BY MASHED POTATOES.

25. Bread is very often mixed with fecula, or with mashed potatoes, sometimes to the extent of 50 per cent. Such bread, however, is not unwholesome, but a given weight of it contains much less nourishment than pure wheat bread, and consequently, if sold under the name, and at or near the price of genuine bread, it is a fraud on the public, and more especially upon the poor. This admixture is not otherwise objectionable.

26. According to MM. Robine and Parisot, potato-flour may be detected in bread in the following manner:—Put about 100 grains of the suspected bread into a glass-beaker and pour upon them first, one fluid ounce of distilled water, and then one fluid ounce also of aqueous solution of iodine, (prepared by digesting about 100 grains of iodine in one pint of water, and using the supernatant liquor.) If the bread contains any fecula the liquor will assume a crimson tinge which will increase according to the quantity of potato-starch present. When pure wheat-bread is submitted to the same treatment at first no colouring is produced, but about a quarter of an hour after the addition of the water of iodine,

streaks of a purple or violet colour begin to appear from upwards downwards, and in the course of half an hour the liquor acquires a light blue tinge, the intensity of which is seen gradually augmenting. No bread, I believe, exists in London free from admixture with mashed potatoes.

ADULTERATION WITH MASHED BEANS OR WITH BEAN
FLOUR.

27. Whether bread has been adulterated with beans may be ascertained in two ways.

28. *First.* Put 1000 grains of the crumb in a lump into a glass beaker, and pour upon them one ounce of pure water, and then one ounce of water of iodine, prepared as above said. If the bread be pure, no colouring takes place, except a quarter of an hour after the addition of the water of iodine, when blue streaks begin to appear from upwards downwards; and in the course of half an hour the liquor acquires a blue tinge, gradually augmenting in depth or intensity. But if the bread contain bean-flour, or mashed beans, no colouring whatever takes place before half an hour has elapsed, when a slight tinge becomes observable, but the blue streaks above mentioned are never produced as with pure bread.

29. The *second process* consists in crumbling 100 grains of the bread under examination, tritulating them in a porcelain or Wedgewood mortar with 100 grains of sand, gradually adding, pending the trituration, enough water to form a semi-solid paste, which is to be diluted afterwards with about three more ounces of water. The whole is then left at rest for some time, and the supernatant liquor is thrown upon a filter. To one ounce of the filtrate add now one ounce of the water of iodine, and leave the whole at rest. If the bread is pure, the liquor assumes a blue colour, which persists for three or four hours; whilst, if the bread contains bean-flour, the blue colour of the liquor is much less intense, and disappears, either in a short time or almost immediately,

according to the quantity of the bean-flour present in the bread.

30. The *Pharmaceutical Times* of July 15, 1848, contains an article on the adulteration of bread and of flour, by M. Letulle, which we reproduce here.

“The flour of rice is rarely, and only in exceptional cases, mixed with wheaten flour, whilst that of maize is often employed for that purpose. M. Donny detects the presence of the flour of rice and maize, on microscopic examination, by the angular fragments which are not to be found in wheaten flour, fragments which are produced from the exterior part of the perisperm, which in rice and maize is always hard and horny, but farinaceous and pulverulent in even the coarsest wheat.

“To test the suspected flour, M. Donny advises, in the first instance, to separate the gluten by the ordinary mechanical method, to collect the starch, and to submit it (more particularly the coarsest part, which subsides most readily in water) to the microscopic inspection, which will at once detect the angular fragments; a microscope of feeble magnifying power should be used, since this will enable the operator more readily to distinguish these fragments from the grains of starch which envelope them.

“Besides these characters, pointed out by M. Donny, the flour of rice, placed in contact with a solution of potash in the proportion of two per cent., or with water, and submitted to examination by the microscope, may be readily distinguished by the diameter of its starch-grains, which varies between $\frac{1}{200}$ th to $\frac{1}{500}$ th of a millimetre.

“With respect to the flour of maize,* I have discovered

* “I read, this very moment, in the ‘*Répertoire de Pharmacie*’ of last month (June, 1848) that M. Tilhol, professor of chemistry to the Faculty of Sciences of Toulouse, has observed the yellow colouration which the flour of maize acquires under the influence of solution of potash. I cannot but feel pleased to find that a man whose name is so advantageously known to

a certain peculiarity in it which will serve to distinguish it from wheat, viz., solution of potash, with twelve or fourteen per cent. of distilled water, imparts to maize-flour a slight greenish-yellow tint. To produce the colouration, the suspected flour, mixed with a small quantity of the solution of potash, is placed in a cup, and one of the most transparent parts put on a glass plate ; if maize be present, the flour, on imbibing moisture, contracts a greenish-yellow tint, readily distinguishable by the naked eye ; on viewing it under the microscope, a greater or less number of cells of a beautiful bright greenish-yellow are observed ; these cells may appear under two different forms. I have by this means detected maize mixed with wheaten flour, in the proportion of from five to ten per cent. Wishing to ascertain whether the presence of maize in bread may be detected by this re-action, I had some bread made containing about ten per cent. of maize. This bread presented the appearance of bread made of pure wheaten flour, being very white and of good flavour. Placed in contact with the solution of potash, the yellow colour became manifest ; having left the bread for some time to imbibe the solution, a small part of the most transparent portion was examined under the microscope ; the cells were found to exhibit the peculiar bright greenish-yellow tint, which I look upon as the characteristic sign of the presence of maize. I have invariably succeeded with this means in detecting the presence of maize in flour adulterated with that substance.

“ Pure wheaten flour, and bread prepared with it, have

science should thus have arrived at the same results to which my own experiments have led me, since this coincidence cannot fail to confirm the validity of the test which I here propose. But the same characteristic property which M. Tilhol would as yet seem to confine to maize alone exists also, though in a less degree, in barley, oats, and rye. M. Tilhol also expresses the same opinion with myself regarding the impossibility of detecting, by the tests indicating the presence of ‘legumine,’ the adulteration of wheaten flour with leguminous substances.”

never exhibited to me a similar yellow colour under the microscope; but the case is different with other cereals. Thus the flour of barley, rye, and oats, treated with potash in the manner described, exhibits likewise a yellow colour, but of a paler hue; in case of admixture of maize to the flour of these cereals, the yellow colour alone is not sufficient to warrant the operator to assume the presence of maize, since this may be confounded with the other three cereals; in such cases, therefore, we require some additional proof, and this is supplied by the form of the cells of the maize. I have stated already that these cells affect two different forms; the one inclines more or less to the quadrangular or hexagonal form, the other presents the shape of elongated cells; whereas barley, oats, and rye present vast elongated and partitioned cells; some of the grains of maize are of angular shape like rice.

“Barley and oats, which also serve sometimes to adulterate the flour of wheat, may be distinguished by the size of their starch-grains, the diameter of which varies between $\frac{1}{33}$ th to $\frac{1}{50}$ th of a millimetre.

“When flour adulterated with barley and oats is placed in contact with a solution of potash of twelve per cent., and examined under the microscope, we perceive the elongated and partitioned cells, which exhibit the same yellow colour as those of maize, but much less marked, as we have already stated. Bread containing ten per cent. of barley or oats presents an appearance but little different from that of ordinary wheaten bread, and preserves the look of freshness for a longer time; the taste, too, is that of ordinary bread; it is not quite so white as the latter, especially when containing oats. When brought in contact with the solution of potash the partitioned cells may be readily discovered. A small proportion of rye is also sometimes used to adulterate wheaten flour and bread; this may be readily detected by the diameter of its starch-grains, which is the same with that of barley and oats; besides, in contact with solution of potash

(of fourteen per cent.), its cells exhibit the same appearance with those of barley and oats. Where rye by itself is placed in contact with pure water the cells are also visible, but not so distinctly marked. Rye-bread and wheaten bread, containing an admixture of rye, present a similar re-action."

32. Dr. Ure in his Supplement to his "Dictionary of Arts, Manufactures, and Mines," article *Bread*, page 39, remarks:—

"The richness or nutritive powers of sound flour and also of bread are proportional to the quantity of gluten they contain. It is of great importance to determine this point, for both of these objects are of enormous value and consumption; and it may be accomplished most easily and exactly by digesting in a water-bath, at the temperature of 167° Fahr., 1000 grains of bread (or flour) with 1000 grains of bruised barley-malt, in 5000 grains, or in a little more than half a pint, of water. When this mixture ceases to take a blue colour from iodine (that is, when all the starch is converted into soluble dextrine) the gluten left unchanged may be collected on a filter cloth, washed, dried at a heat of 212°, and weighed. The colour, texture, and taste of the gluten ought also to be examined, in forming a judgment of good flour or bread.

"Independently of the skill of the baker, bread varies in quality according to the quantity of water and gluten it contains. A patent of German or French origin was obtained here a few years ago, for manufacturing loaf-bread by using thin boiled flour-paste instead of water for setting the sponge, that is, for the preliminary dough fermentation. By this artifice, 104 loaves of 4lbs. each could be made out of a sack of flour, instead of 94, as in ordinary baking; because the boiled paste gave a water-keeping faculty to the bread in that proportion. But this *hydrated* bread was apt to spoil

in warm weather, and became an unprofitable speculation to all concerned.

“Bread and flour are often adulterated in France with potato starch, but almost never, I believe, in this country.* This sophistication is easily detected by the microscope, on account of the peculiar ovoid shape and the large size of the particles of the potato fecula. Horse-bean flour gives to wheaten bread a pinkish tint. In spoiled flour (such as is too often used, partially at least, by our inferior bakers) the gluten sometimes disappears altogether, and is replaced by ammoniacal salts.† In this case, quick-lime separates ammonia from the flour without heat; in flour slightly damaged, or ground from damaged wheat, the gluten present is deprived of its elasticity, and is softer than in the natural state. On this account, the gluten test of M. Boland is valuable. It consists in putting some gluten into the bottom of a copper tube, and heating that tube in an oven, or in oil at a temperature of 284° Fahr. The length to which the cylinder of gluten expands is proportional to, and indicates its quality.

“It appears that a French sack of flour, which weighs 159 kilogrammes, affords from 102 to 106 loaves of 2 kilogrammes each : and therefore,

“159 : 52.0 : : 280 : 91.6 ; that is, if 159 kilogs. or lbs. afford 52 loaves of 4 kilogs. or lbs., 280lbs., a sack English, should afford 91.6 loaves of 4lbs. each ; but our bakers usually make out 94 loaves, which are rated at 4lbs. though they seldom weigh so much. The loaves of a baker in my neighbourhood, who supplied my family with bread for some

* It may be, that bread is never adulterated in this country with *potato starch* ; but that *mashed potatoes* are mixed with a little flour, fermented with yeast, and then introduced into the dough, by every baker in London, I should say, probably without exception, is an incontrovertible fact.

† Dumas, *Chimie Appliquée*, vi. 425.

time, were found on trial to be from 6 to 8 oz. deficient in weight ; when challenged for this fraud, he had the effrontery to palliate it by alleging that all his neighbour bakers did the same. It must be borne in mind, that a Paris loaf of 2lbs. or 2 kilogs. contains more dry farina than a London loaf of like weight ; for it contains, from its form and texture, more crust. The crumb is to the crust in the Paris long loaves, as 25 to 75, or 1 to 3 : in our quartern loaves it is as 18 or 20 to 100.

“ M. Dumas gives the following Table :—

Weight of a Sack of Flour.	Number of Loaves.	Weight of the Bread.	Increase of Weight of Flour.	Ratio of dry flour = 1, to Bread.
159 Kilogs.	102	202 Kilogs.	1.283	1 : 1.60
159 do.	104	208 do.	1.300	
159 do.	106	212 do.	1.333	

“ Thus it would appear that the mean yield would correspond to 130 kilogs. of bread for 100 of the flour employed ; and admitting that common flour contains 0.17 of water, the product would be equivalent to 150 of bread for 100 of flour absolutely dry. The whole loaf contains 66 per cent. of dry substance, and the crumb only 44.”

To the fact, which I mentioned at the beginning of this article, that in all the samples of bread which I examined, alum was invariably present, I am happy to say, that I lately met with one exception, and I would fain hope that there are a few more. I am alluding to the bread made by a baker in Judd Street, Mr. Gilbertson, which I can confidently assert, does not contain a particle of alum. His loaves, however, like, I believe, those of all other bakers, contain a certain quantity of potato-flour, or pulp. This addition, however, is not detrimental to the quality or wholesomeness of the bread, and is a mere matter of economy,—I mean economy to the baker.

Bread, really pure, that is made altogether of genuine

wheat-flour, is, I have no doubt, to be found no where in London.

33. Although bread and flour are now adulterated without interference, it should be known that it is an offence punishable by law.

34. The Act of Parliament, 1 and 2 Geo. IV., cap. 50, § 6, says :—

“Bakers, either journeymen or masters, using alum, or any other unwholesome ingredient, and convicted on their own confession, or on the oath of one or more witnesses, to forfeit not exceeding £20 and not less than £5, if beyond the environs of London ; and not exceeding £10, nor less than £5, if within London or its environs. Justices are allowed to publish the names of offenders. The adulteration of meal or flour is punishable by a like penalty. Loaves made of any other grain than wheat, without the city and in its liberties, or beyond ten miles of the Royal Exchange, to be marked with a large Roman M; and every person exposing such loaves without such mark, shall forfeit not more than 40s. nor less than 10s. for every loaf so exposed.” Any ingredient or mixture found, within the house, mill, stall, shop, &c., of any miller, mealman, or baker, which, after due examination shall be adjudged to have been placed there for the purpose of adulteration, shall be forfeited ; and the person within whose premises it is found, punished, if within the city of London and its environs, by a penalty not exceeding £10 nor less than £2 for the first offence, £5 for the second offence, and £10 for every subsequent offence (3 Geo. IV. cap. 106, § 14) ; and if without London and its environs, the party in whose house or premises ingredients for adulteration shall be found, shall forfeit, for every such offence, not less than £5, and not more than £20 (1 and 2 Geo. IV. cap. 5, § 8).

35. Such are the legislative regulations on the matter ;

but they are practically of no avail, and the admixture of alum with bread is general amongst bakers, just as if the law did not exist. It is said that the Act cannot be put in force, because its provisions are evaded by the bakers not keeping the adulterating substances on their premises, but sending them to the mill, there to be mixed with the flour. I have every reason to believe, however, that this is not the case, but that the introduction of alum with the flour actually takes place at the baking-house. I know, moreover, as a fact, that many wholesale druggists keep for the use of bakers what is called *bakers' alum*, that is, pulverized alum, adulterated with a certain quantity of common salt, and that it is sold to bakers, and delivered at their shops in that state. Admitting, however, that the mixing of alum with the flour takes place at the mill, it does not appear to me that such an evasion of the law could at all shelter the delinquent; for if flour or the bread is found on the bakers' premises to contain alum, surely the drug might be legally considered as being on the premises. It is true that the alum is then in a *mixed state*, but the law does not say any thing regarding the state in which it may be; it declares only, that the *use of alum, or of any other unwholesome ingredient* in flour is a punishable offence. At any rate, the practice of the miller clearly comes under the provisions of the Act, and it should therefore be enforced against him; but, says Dr. Ure, "who would choose to incur the trouble, responsibility, and expense of prosecuting a frequent misdemeanour of this kind?" The answer might be:—A board of competent gentlemen of acknowledged talent and probity, a Board of Health, as on the Continent. (See *Flour*.)

BRIMSTONE.—See *Sulphur*.

BRITANNIA METAL.—See *Antimony*.

BRITISH BARILLA.—See *Kelp*.

B R O M I N E.

1. This substance, which is now used to some considerable extent for the daguerreotype and other purposes, is a liquid of a deep reddish brown colour, of a disagreeable, suffocating odour resembling that of chlorine gas. Its specific gravity is 2.966, and, when pure, it boils at 116° Fahr. The bromine of commerce, however, often requires a temperature of 248° Fahr. to boil, which, according to M. Poselger, is owing to the presence of variable proportions of bromide of carbon, resulting from the simultaneous action of bromine upon the ether and alcohol employed in its preparation.

2. Bromine may be purified by distilling and collecting only the first portions that pass over.

3. Pure bromine is only sparingly soluble in water ; but it dissolves better in alcohol. Its best solvent, however, is ether.

4. M. Poselger in the “Poggendorf’s Annalen,” says :—

“During the distillation of certain samples of bromine of commerce, I observed that the boiling point of the liquid stood at 478.4 instead of 251.6 Fahr., and that the liquid acquired a lighter and lighter colour, and became in the end perfectly colourless. I carried the distillation to dryness, and found a residue of charcoal.

“In separating the bromine from the last portion of

the distilled liquid, by means of a solution of potash, an oily, aromatic, colourless liquid was obtained, which upon analysis turned out to be bromide of carbon.

“This admixture of bromide of carbon was found in divers samples of bromine of commerce to the extent of six to eight per cent. of the article.

“It is most probable that the bromide of carbon owes its origin here to the ether used for the preparation of the bromine.”

B R O N Z E.

BELL-METAL. GUN-METAL.

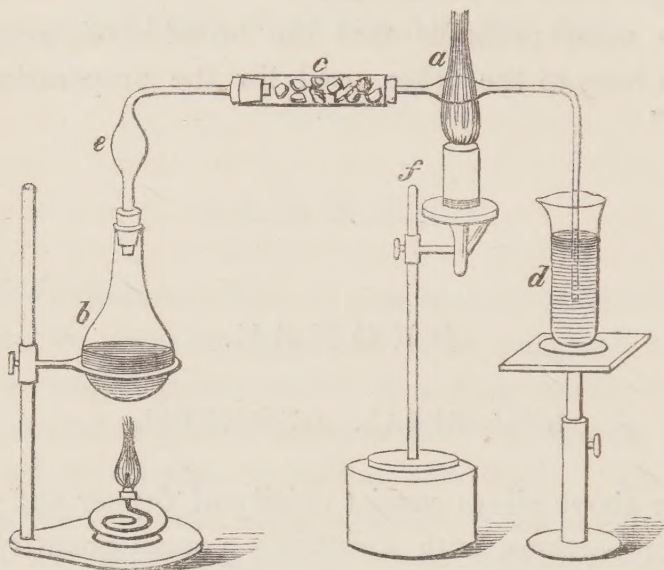
1. The above alloys consist chiefly of copper and of tin in various proportions, with sometimes a small quantity of zinc or of lead, or of both zinc and lead. The results of several analyses are as follow :—

Bronze of Cannons.	Speculum Metal or Mirrors of Telescopes.	Coins or Medals.	Gongs or Cymbals.	Gun Metal, Statues, and large Castings.	Bell Metal.
Copper 100	66	93 — 89	78 — 80	92 — 89	80 — 83
Tin 11	33	7 — 11	22 — 20	8 — 11	10 — 17
Zinc „	„	„ „	„ „	„ „	6 — „
Lead „	„	„ „	„ „	„ „	4 — „
111	99	100—100	100—100	100—100	100—100

ANALYSIS OF BRONZE, BELL, OR GUN-METAL.

2. When the proportion of the tin contained in the alloy has not to be determined with extreme accuracy, or when the alloy contains only a small quantity of it, the process which has been described for the analysis of brass may be

adopted, but if the quantity of tin contained in the alloy is more considerable, that method cannot be much recommended, where correctness is required, because the insoluble peroxyde of tin produced by the action of the nitric acid, always retains about $\frac{1}{12}$ of oxyde of copper.



3. Mr. Sobrero's process gives accurate results. It consists in heating 50 grains of the alloy in a glass bulb *a*, through which a stream of dry chlorine gas, issuing from a flask *b*, is passed. The flask *b c* contains a mixture of peroxyde of manganese and hydrochloric acid. One of the extremities of the bulbous tube *a* is connected with a tube *c*, filled with pieces of fused chloride of calcium; the other end, which should be at least six inches long, plunges in a vessel *d*, containing dilute hydrochloric acid. The apparatus being disposed as in the figure, the flask *b* should be gently heated; the stream of chlorine gas first abandons a portion of its moisture which condenses in the bulb *e*, before traversing the tube *c* containing chloride of calcium, by which it is completely dried; and passing thence over the alloy in the bulb *a*, in which it is heated by the argand spirit-lamp *f*, or by my gas-lamp furnace, the tin, the zinc, and the iron (if any be

present), are soon converted into chlorides of these metals, which being volatile, pass into the vessel *d* containing the dilute hydrochloric acid, whilst the chlorides of lead and of copper being fixed, remain in the bulb; care must be taken not to disengage the gas too rapidly. This being done, the flask from which the chlorine was disengaged is disconnected, and another flask, containing sulphuric acid and zinc, is substituted thereto, for the purpose of generating hydrogen gas, a current of which is then passed through the chlorides of lead and of copper in the bulb, by which means they are reduced to the metallic state. The apparatus is then taken asunder, the bulb is weighed with its contents, after which it is plunged into dilute nitric acid, which dissolves the copper and the lead. The bulb must now be weighed again, and the difference between the two weighings gives, of course, the joint weight of the two metals which were dissolved by the nitric acid as just said. The quantity of the lead in the solution is then precipitated by sulphuric acid, and weighed as sulphate of lead, exactly in the same manner as was described for the analysis of brass. (See *Brass*.) The difference in the joint weight indicates, of course, the quantity of the copper; or this latter metal may be directly estimated by precipitating the liquor filtered from the sulphate of lead, as was already described in the analysis of brass. (See *Brass*.)

4. The tin which exists in the state of chloride of tin in the vessel containing water and hydrochloric acid, which received the volatile chlorides evolved in the first part of the experiment, is separated in the state of sulphuret of tin by means of sulphuretted hydrogen, and the liquor is left to digest, at a gentle heat, until it no longer exhales the slightest odour of sulphuretted hydrogen. The liquor is then filtered from the precipitate; the latter is washed, dried, put in a platinum crucible, and gently heated therein until all evolution of sulphurous fumes has ceased, the temperature is then increased to a bright red heat, and in order to make sure that all trace of sulphuric acid produced by the roasting

has ceased, a small piece of carbonate of ammonia is placed upon the peroxyde of tin obtained, and the whole is strongly heated. The crucible is then allowed to cool, and it is weighed. 74 of peroxyde of tin contain 58 of tin, or 1 part in weight of peroxyde of tin, $S_n O_2 = \text{tin } 0.78616 + \text{oxygen } 0.21384$.

5. In igniting the sulphuret of tin, as above mentioned, it is necessary that the heat should be, at first, very moderate; because, if a strong heat were applied at once, half of the sulphur and the protosulphuret of tin left would fuse, and the crucible would be damaged. This, however, is the only objection, for the equivalent of peroxyde of tin, and that of protosulphuret of the same metal is the same; that is to say, 74 grains of protosulphuret of tin contain also 58 of tin or one part in weight of protosulphuret of tin, $S_n S$ contains tin 0.78519 + sulphur 0.21481.

6. The zinc contained in the liquor filtered from the sulphuret of tin may be precipitated by carbonate of soda, exactly as we described in the analysis of brass; but if iron be present at the same time, it is advisable to separate it in the following manner:—to the acid liquor, ammonia is to be added until it be very slightly supersaturated; that is to say, until a few reddish brown flakes of peroxyde of iron begin to appear. A solution of neutral succinate of ammonia is then added in sufficient quantity to precipitate the whole of the iron as persuccinate of iron. This precipitate is collected on a filter, washed, dried, and ignited in a platinum crucible. In order to facilitate the combustion of the organic substance, the cover of the crucible is to be placed half way across the crucible, in order to determine a current of air; or, which is still more effective, the crucible is to be placed flat on one side, and the cover is put by the side of it and before its mouth, whilst the ignition is going on. The residuum is peroxyde of iron, 80 gr. of which contain 56 of iron; or one part of peroxyde of iron $Fe_2 O_3$ contains, iron 0.69338, and oxygen 0.30662.

7. The filtrate from the persuccinate of iron is now treated by carbonate of soda and boiled, in order to decompose the ammoniacal salt, and the whole is evaporated to dryness, which is best done by putting the liquor in a Florence flask, inclined at an angle of about 45° , in order to prevent loss by spirting, and the solution of carbonate of soda is added until all odour of ammonia has disappeared; or rather, until a glass rod, moistened with moderately dilute hydrochloric acid, ceases to produce white fumes when held at the mouth of the flask. The whole being evaporated to dryness, a large quantity of hot water is poured upon the residuum, and the whole is boiled; the insoluble portion is carbonate of zinc, which may be collected on a filter, washed, dried, and ignited, by which means it is converted into oxyde of zinc, in which state it is weighed. 40 grains of oxyde of zinc contain 32 of zinc; or one part of oxyde of zinc $Z_n O$ contains zinc 0.80128, oxygen 0.19872.

8. The presence of *arsenic* in bronze, copper, lead, and tin, may be detected by Mr. Levöl's process as follows:—the metal is to be dissolved in nitric acid; all the arsenic remains with the peroxyde of tin (metastannic acid) in the state of arsenic acid; the solution does not retain any arsenic. The combination of peroxyde of tin and of arsenic is then separated from the liquor by filtering; it is washed, dried, and exposed in a tube at a red heat, to a stream of pure and dry hydrogen gas, by which it is decomposed; the arsenic is reduced; it volatilizes and condenses in the cold part of the tube in the form of a bright metallic ring of arsenic, which may be easily recognized as such by the usual characteristics of arsenic; that is to say, by its shifting from place to place in the tube, on applying the flame of a spirit-lamp, and by the odour of garlic which is emitted when it is volatilized in the air. The tin which remains in the tube, and which still retains traces of arsenic, may be treated by Marsh's apparatus with hydrochloric acid, by which means the usual arsenical spots and ring may be obtained. (See the Glossary at the

end, *Marsh's Apparatus*.) This method is applicable, not only to the analysis of bronze, but likewise to that of copper, lead, and other metals which may contain arsenic, even when no tin is present; for in that case, it is sufficient to add a little tin before the treatment with nitric acid.

9. When bronze, or the other alloys of copper, contains *lead*, the latter metal may be separated, according to M. de Massas, in the following manner:—

The bronze is to be treated by a large excess of nitric acid, the solution is then diluted with water, and the tin, if any be present, being thereby converted into an insoluble peroxyde of tin (metastannic acid), is collected on a filter and washed. A small quantity of pernitrate of iron (in the proportion of 4 or 5 grains of iron for 15 grains of bronze) is then added to the liquor, by which the oxyde of lead and peroxyde of iron are precipitated conjointly with a small quantity of oxyde of copper. This precipitate is washed until the liquor filters colourless; after which it is detached from the filter and digested in a glass beaker, with a small quantity of dilute sulphuric acid. The oxydes of iron and of copper are thereby dissolved, whilst the oxyde of lead remains in the state of insoluble sulphate of lead.

BUTTER OF COCOA.—(See *Oils*.)

CAJEPUT OIL.

1. Cajeput oil is an essential or volatile oil extracted by distillation from the dried leaves of the cajeput tree (*Melaleuca leucadendron*, *Melaleuca cajeputi*, *Melaleuca leucadendron* of Linnæus), which grows at Amboyne, Borneo, and other Eastern Islands. It is transparent, of a fine green colour, very fluid, lighter than water, very volatile. It has a strong odour resembling that of a mixture of camphor, and oil of turpentine, or rather of camphor and cardamoms; it

has a pungent and fresh taste, analogous to that of camphor. The green colour is often due to the presence of oxyde of copper, from the copper flasks in which it is generally imported, but this colour does not seem to be altogether referrible to that substance, for according to Leverkühn, the green cajeput oil consists of two oils which may be isolated by distillation ; at first the $\frac{1}{3}$ th of the oil operated upon pass off in a colourless state, and of a specific gravity 0.897 ; then a green oil comes over much more slowly, and of a specific gravity 0.920, of a more feeble odour and more acrid taste.

2. The presence of copper is easily detected in cajeput oil, by pouring some very dilute hydrochloric acid in the oil, and shaking the whole well, decanting the oil, and pouring a solution of ferrocyanuret of potassium in the residuary liquor which will then assume a red or reddish brown colour from the precipitate of ferrocyanide of copper produced.

3. The presence of copper may also be recognized by immersing a bar of bright iron in the liquor treated as above said, when a deposit of metallic copper will take place on the bar of iron.

4. Cajeput oil is often adulterated with essential oil of turpentine, of rosemary, or of savine with addition of camphor, &c., and coloured with rosin of milfoil (*achillea millefolium*.)

CALAMINE.—See *Zinc Ores*.

CALOMEL.

SUBCHLORIDE OF MERCURY. PROTOCHLORIDE OF MERCURY. AQUILA ALBA. MERCURIUS DULCIS.

1. Calomel is a compound of mercury and of chlorine ($\text{Hg}_2 \text{Cl}_2$) white, inodorous, tasteless, semi-transparent, volatilizable by heat, but less readily than corrosive subli-

mate (Hg, Cl.) When pulverized it has a pale yellow colour, but it becomes blackish or grey by exposure to solar light. It is almost insoluble in *cold* water, but is soluble in about 12000 parts of boiling water.

2. Calomel is often adulterated, to a considerable extent, by an admixture of various white powders, such as *chalk*, *sulphate of baryta*, *white lead*, and is sometimes contaminated by some *corrosive sublimate* carelessly left in it by insufficient washing ; also by *common salt* and by *sal-ammoniac*.

3. As, however, calomel is completely volatilizable by heat, the fixed impurities may be readily detected and determined, by igniting a given weight of the sample.

4. In order to ascertain the nature of the fixed impurities, the residuum left after ignition should be treated by dilute hydrochloric acid. If an insoluble residuum be left, it may consist of *sulphate of baryta*, or of *lead*. These are distinguished from each other by moistening the insoluble residuum with hydrosulphuret of ammonia, which will render it black if it consist of sulphate of lead, but which will leave it white if it consist of sulphate of baryta. If, on treating the residuum by hydrochloric acid, an effervescence is produced, a carbonate is present, which may be *chalk* (carbonate of lime), or *white lead* (carbonate of lead). The same test as above mentioned, namely hydrosulphuret of ammonia, will identify which it is, for if it be carbonate of lead, the residuum will turn black ; and if it be carbonate of lime, it will remain white. Or, after having dissolved (with effervescence) the residuum left after ignition, in hydrochloric acid as just said, a current of sulphuretted hydrogen passed through the solution will produce a black precipitate of sulphuret of lead, if lead is present ; and if the liquor filtered from this precipitate, or in which sulphuretted hydrogen failed in producing a precipitate, being first neutralized by ammonia, and then tested with oxalate of ammonia, yields a white precipitate, it is oxalate of ammonia, and the adulteration, therefore, was chalk.

5. The presence of *corrosive sublimate* is always an unintentional impurity resulting from carelessness, or neglect; the presence of this virulent poison is detected in calomel by pouring *cold* water on a given weight of the sample, and throwing the whole on a paper-filter. The cold water dissolves the corrosive sublimate and filters through whilst, the calomel remains altogether on the filter. The filtrate, being now tested by solution of nitrate of silver, will produce a white precipitate of chloride of silver; or a black precipitate of sulphuret of mercury, if tested by sulphuretted hydrogen.

6. The quantity of corrosive sublimate being generally exceedingly small, is best determined by means of a test solution of nitrate of silver as follows:—

7. Since 136 grains (one equivalent) of corrosive sublimate contain 36 grains (one equivalent) of chlorine, 100 grains of that substance contains, therefore, 26.47 of chlorine, which will require 79.41 of silver, and consequently very nearly 125 grains of nitrate of silver.

8. Dissolve, therefore, 125 grains of nitrate of silver in 10,000 grains-measure of water, and mark it “Centesimal test liquor of nitrate of silver for corrosive sublimate.” 1000 grains-measure of such solution represent 100 grains, and each measure, of course, $\frac{1}{10}$ th of a grain of corrosive sublimate.

9. Proceed now as follows, for the estimation of corrosive sublimate. Take 100 grains of the calomel under examination, wash them thoroughly on a filter with distilled *cold* water, until a drop of the filtrate being carefully evaporated on a strip of platinum foil, leaves no residuum. Test then the whole filtrate with the centesimal solution of nitrate of silver above mentioned, by putting 1000 grains-measure of it into an alkalimeter, and pouring it therefrom, drop by drop, into the filtrate, until it ceases to produce a precipitate, which may be exactly ascertained by filtering or decanting a clear portion of the filtrate after each successive addition of the nitrate of silver test-liquor. Suppose, now, that five

divisions, or measures, have been employed, it shows that the calomel was contaminated by $\frac{1}{2}$ per cent. of corrosive sublimate.

10. Or instead of taking 1000 grains-measure (100 divisions of the alkalimeter) of the test liquor, only 100 grains-measure (10 measures of the alkalimeter) may be poured into the alkalimeter, and the rest of the divisions being filled with water, each division will now represent only $\frac{1}{100}$ th of a grain of corrosive sublimate, and in the above case, supposing the calomel to have contained $\frac{1}{2}$ per cent. of corrosive sublimate, 50 alkalimetrical divisions of the test liquor of nitrate of silver, diluted as above said, would of course be required.

11. Or, instead of this centesimal test liquor, an equivalent test liquor of nitrate of silver may be prepared, by dissolving one equivalent, or 170 grains of nitrate of silver in 1000 measures of distilled water, and this, of course, will represent one equivalent of chlorine (36 grains), or one equivalent of corrosive sublimate (136 grains), and consequently each measure of the alkalimeter will indicate 0.36 of chlorine, or 1.36 of corrosive sublimate. If now 100 grains-measure (10 alkalimetrical divisions) of this test liquor be poured in the alkalimeter, and the rest of the divisions filled with water, it is evident that each division will now represent only 0.136 of corrosive sublimate. But the test solution may be further diluted, if necessary, in order to indicate smaller fractions.

12. The presence of corrosive sublimate may also be detected by digesting the calomel in alcohol, and adding caustic potash to the liquor. The corrosive sublimate, if any have dissolved, will then produce a yellow, or reddish-brown precipitate of hydrate of peroxyde of mercury.

13. If the calomel under examination contain any *sub-nitrate of mercury*, its presence may be detected by digesting the calomel at a gentle heat with water, acidified by nitric acid, and adding an alkali to the liquor which will precipitate the subsalt which it may hold in solution.

14. Or else a small portion of the calomel is to be heated

in a small tube closed at one end ; if ruddy fumes of nitrous acid appear, it indicates the presence of the nitrate.

15. But the most delicate test for the detection of a nitrate consists in washing the calomel with cold water, concentrating the filtrate by evaporation, and pouring into a small glass-beaker about 50 grains-measure of *pure* concentrated sulphuric acid, and of course free from nitric acid, and then adding a few drops of the concentrated filtrate. The whole being stirred with a glass rod, if a small particle of *brucine* be now taken up and transferred to the acid liquor in the glass beaker, and the whole be well stirred, the liquor will, after a short time, become red and then yellow, if a nitrate is present. Or a small quantity of the calomel may be heated in a test tube with two or three drops of pure sulphuric acid, and then a crystal of morphia being added, the mass will become orange red and then yellow, if a nitrate is present. Either of these tests will detect $\frac{1}{10000}$ th part of nitric acid.

CAPIVI.—See *Copaiba*.

CAPSICUM.—See *Cayenne Pepper*.

CARBONATE OF AMMONIA.

SESQUICARBONATE OF AMMONIA. SMELLING SALTS.

1. The sesquicarbonate of ammonia of commerce often contains *sal ammoniac*, *sulphate of ammonia*, some *organic matter*, and also sometimes traces of *carbonate of lead*, or a *salt of lime*. These impurities are detected as follows :—

2. Pure sesquicarbonate of ammonia, being heated in a pla-

tinum crucible should evaporate without residuum. If a carbonaceous residue is left, it is owing to the presence of organic matter; if it is fixed, it may be carbonate of lead, or a salt of lime, which are distinguished from each other by moistening the residue with hydrosulphuret of ammonia, by which it will be blackened if lead is present; whilst it will undergo no change of colour, if it consists of lime. Moreover, if the ammoniacal salt contains carbonate of lead, the latter substance will remain in an insoluble state in treating the salt with water.

3. If *sal ammoniac*, or any other chloride be present, the sesquicarbonate of ammonia under examination should be dissolved in water, and the solution, being tested by nitrate of silver, will then produce a white turbidness or precipitate, according to the amount of the chloride present.

4. If sesquicarbonate of ammonia be contaminated by *sulphate of ammonia*, an addition of nitrate of baryta to the aqueous solution of the salt previously supersaturated with nitric acid, will produce a precipitate of sulphate of baryta.

5. As these impurities exist generally in exceedingly small quantities only, their amount is best estimated by means of test-liquors of nitrate of silver, or of baryta, of a known strength. The analytical process is then managed exactly as was described in the articles on alkalimetry or acidimetry.

6. When sesquicarbonate of ammonia is contaminated by *empyreumatic oil*, it leaves a small carbonaceous residuum after ignition, as we said at the beginning of this article, and its solution in dilute acids is brown or even black.

7. As sesquicarbonate of ammonia when left exposed to the air, becomes gradually converted into bicarbonate of ammonia, a little of the latter salt is always present.

8. Pure sesquicarbonate of ammonia is translucid and colourless.

CARBONATE OF BARYTA.

1. Carbonate of baryta is often adulterated with *sulphate of baryta*, or, at any rate, that which is sold as carbonate of baryta contains sometimes an extremely large proportion of sulphate of baryta, the presence of which, however, is easily detected by dissolving a portion of the sample in dilute hydrochloric or nitric acid. If sulphate of baryta is present, it will remain in an insoluble state, for carbonate of baryta is completely soluble in both these acids.

2. Sulphuric acid being poured in, the above solution should reprecipitate the whole of the baryta in the state of sulphate of baryta, which being washed, dried, ignited, and weighed, should be in the proportion of 117 grains for every 99 grains of carbonate of baryta operated upon, and the liquor filtered from the sulphate of baryta so produced, should not yield the slightest precipitate by caustic ammonia, nor by hydrosulphuret of ammonia, carbonate of potash, or of soda, oxalate of ammonia, or other re-agents. Any precipitate which may be so produced is an impurity.

3. Whether the carbonate of baryta under examination is pure or not, may also be ascertained, by boiling a certain quantity of it in distilled water, filtering and evaporating the filtrate to dryness. If a residuum is left, it is an impurity. Yet Dr. Fresenius has shown that carbonate of baryta is not *altogether* insoluble in water, since 14137 parts of water dissolve one part of carbonate of baryta.

CARBONATE OF COPPER.—See *Copper Ores*.

CARBONATE OF LEAD.

WHITE LEAD. HAMBURG WHITE. DUTCH WHITE.
VENICE WHITE.

1. White lead is a combination of carbonic acid and of lead (PbO , CO_2), of a fine white colour, insoluble in water ; it is decomposed by a red heat, which expels the carbonic acid and leaves protoxyde of lead.

2. White lead is a most important article of commerce ; it forms the base of all oil-paints, and of glaziers' cement.

3. The genuine white lead of commerce, however, is not altogether pure carbonate of lead ; it contains also generally a small portion of hydrated oxyde of lead, the presence of which appears to be necessary to obtain the fullest covering or coating power.

4. White lead is adulterated to an enormous extent ; the pigments known under the names of *Hamburg white*, *Venice white*, &c., are in reality acknowledged sophistications of that substance.

5. The principal adulterations of white lead are *sulphate of baryta*, *sulphate of lead*, *chalk*, and *lime*.

6. The presence of *sulphate of baryta* and of sulphate of lead may be easily detected by treating a known weight of the white lead (100 grains for example), under examination, with an excess of dilute nitric acid. A slight effervescence is at first produced, and when it is seen, that after having boiled the liquor, and although the acid is in excess, all action has ceased, the whole is poured into a large porcelain capsule and evaporated to dryness at a gentle heat. The dry residuum should then be treated by distilled water, in order to redissolve the nitrates which have been formed, and the whole is thrown on a filter. The precipitate or insoluble portion which is left on the filter, consisting of sulphate of

lead or of sulphate of baryta, should be carefully washed, dried, ignited, and then weighed.

7. In order to detect whether this insoluble portion consists of sulphate of baryta or of sulphate of lead, a few drops of hydrosulphuret of ammonia should be poured upon it, if it turns black, it indicates that the precipitate consists of sulphate of lead; if it remains white, it is sulphate of baryta.

8. As, however, both sulphate of lead and of baryta might be present in the white lead under examination, and, perhaps, also *silica*, in fine powder, it is necessary to proceed as follows :—

9. A portion of the dry residuum, insoluble in dilute nitric acid, as above said, having been well washed and dried, is to be heated before the blow-pipe upon a piece of charcoal, and if upon moistening it with hydrochloric acid, a distinct odour of sulphuretted hydrogen is evolved, the operator may rest assured that sulphate of baryta is present.

10. Admitting, therefore, that these three substances are present, the operator should thoroughly mix the insoluble and well washed residuum with about three times its weight of carbonate of potash, and fuse it for about half an hour in a porcelain crucible, taking care to moderate the heat at first, for fear the mass should boil over. The mass having been fused, and having cooled, is to be treated with hot water, and boiled therewith. The solution is filtered; the filtrate is carefully supersaturated with dilute nitric acid, which should be added by small portions at a time, on account of the effervescence, and the whole is evaporated to dryness. The dry mass being now treated by boiling water, if an insoluble gritty residuum is left, it is *silica*.

11. If the liquor filtered from the silica, being treated by a current of sulphuretted hydrogen, yields a black precipitate, the white lead contained *sulphate of lead*.

12. Sulphate of baryta may be ignited with the filter without fear of converting it into sulphuret of barium, pro-

vided the air be excluded. But as the sulphate of lead would be reduced by the charcoal of the filter, it is better, after drying it, to scrape it off the filter as completely as possible, to burn the filter by itself, and adding the ashes to the sulphate of lead scraped from the filter, to ignite the whole in a porcelain crucible before weighing it.

13. Several varieties of white lead known under the names of *Hamburg white*, *Dutch white*, &c., as above said, are mixtures of carbonate of lead and of sulphate baryta, generally in the proportions of two or three of sulphate of baryta with one of carbonate of lead. Sometimes, also, a pigment is sold as *white lead*, which is scarcely any thing else than sulphate of lead, which is made in the manufactories of floor cloth by decomposing acetate of lead by alum.

14. When white lead is adulterated with *lime* or with *chalk*, these impurities may be detected by dissolving a portion of the sample under examination in very dilute nitric acid, and passing a stream of sulphuretted hydrogen through the solution until it smells strongly of that gas; a black precipitate is thereby produced, which is sulphuret of lead, which should be separated by filtering. The filtrate should then be boiled until all odour of sulphuretted hydrogen has disappeared; and after filtering again, if necessary, the lime contained in solution in the filtrate, may be precipitated by means of oxalate of ammonia in the state of oxalate of lime; or in that of sulphate of lime by means of sulphuric acid and alcohol. In the first case, the filtrate should be neutralized by ammonia, and on adding oxalate of ammonia, a precipitate of oxalate of lime is immediately produced. When the quantity of the lime has to be determined, the liquor containing the precipitate should be left at rest for a long time, because oxalate of lime deposits very slowly; it is, moreover, advisable to boil the liquor, and again to allow it to settle well before filtering, else it will pass turbid through the filter. The precipitated oxalate of lime being collected on a filter, should be washed, dried,

and ignited with the filter in a platinum crucible, pending which operation oxyde of carbon is evolved, which burns with a blue flame, and the residuum, which consists of carbonate of lime, may then be weighed. If the heat has not been too strong in igniting it, the carbonate of lime will have lost none of its carbonic acid, and from its weight, that of the lime present in the sample is calculated. 50 grains of carbonate of lime represent 28 of lime.

15. The determination of the lime, in the state of sulphate of lime, yields more accurate results. In this case sulphuric acid is first poured in the filtrate, and then alcohol; sulphate of lime, being insoluble in aqueous alcohol, is thus precipitated and collected on a filter, washed with dilute alcohol, dried, ignited, and weighed. 68 grains of sulphate of lime represent 28 of lime.

16. The quantity of carbonate of lime present in the white lead, under examination, may also be determined by pouring solution of carbonate of ammonia in the liquor from which the black sulphuret of lead has been separated, filtering and previously boiling it until all odour of sulphuretted hydrogen has disappeared. The addition of solution of carbonate of ammonia will produce a precipitate of carbonate of lime, which may then be collected on a filter, washed, dried, gently ignited, and weighed. The solution of carbonate of ammonia used for this purpose, should first be mixed with a little pure ammonia, and before proceeding to filter the carbonate of lime precipitated, the whole should be left to digest for a pretty long time in a warm place so that it may settle well.

CARBONATE OF MAGNESIA.—See *Magnesia*.

CARBONATE OF SODA.

CRYSTALS.

1. The crystals of carbonate of soda of commerce are often adulterated to an *excessively large* extent, by

mixture with crystals of *sulphate of soda*, which are only half the price of the carbonate, and which, for detergent purposes, are of no value whatever.

2. This fraud is very easily detected, and the amount determined, by dissolving a known weight of the crystals in water, supersaturating the solution with nitric acid, and then adding nitrate of baryta until a precipitate ceases to be produced. The whole is then boiled, the precipitate which is sulphate of baryta is allowed to settle, and collected on a filter. After washing, drying, and igniting it, it is weighed. 117 of sulphate of baryta represent 162 of crystals of sulphate of soda.

3. Sometimes, also, the carbonate of soda of commerce contains *chloride of sodium* (common salt), which is detected by testing the clear solution, acidified with nitric acid) or that filtered from the sulphate of baryta first produced) by solution of nitrate of silver which will produce a precipitate of chloride of silver, if chloride of sodium is present. The whole is then boiled a little, and allowed to settle, the precipitate is separated by filtering, washed, carefully dried, and fused in a small porcelain crucible, after which it is weighed. 144 of chloride of silver represent 60 of chloride of sodium, (common salt.)

4. It should be borne in mind that the crystals of soda of commerce always contain a *trace* of sulphate of soda and of chloride of sodium, and also that they contain 10 equivalents (62.69 per cent.) of water of crystallization.

CARBONATE OF ZINC.—See *Zinc Ores*.

CARMINE.

1. Carmine is a splendid red pigment obtained from cocheneal by a peculiar process. This pigment, being very costly, is often adulterated by an admixture of *starch*, of

alumina, or of *vermillion* ; sometimes, also, a portion of the animal matter of the cocheneal from which it has been obtained is accidentally left mixed with it. These accidental or intentional impurities are readily detected by heating the carmine with liquid ammonia which dissolves entirely the colouring matter, and leaves the impurities in an insoluble state. The residuum left should then be dried at a gentle heat, for which purpose a steam bath answers best, and then weighed.

2. The difference of colour of the carmine of various shops, *when the pigment is genuine*, depends on the quantity of alumina which has been employed to precipitate it, but it depends also upon the carefulness of the manipulation, the purity of the atmosphere, and probably other causes. The preparation of this costly article is not well known, and the secret by which the brightest colour may be obtained is in the possession of only a few persons.

CARTHAMUS.—See *Safflower*.

CAST IRON.—See *Iron*.

CAST STEEL.—See *Steel*.

C A S T O R.

CASTOREUM.

1. Castor is a substance secreted by the beaver, and found in the inguinal region of the animal in four bags, a large and a small one on each side.

2. Whilst the animal is alive, castor is soft, but when the bag which contains it has been removed, it dries up and becomes brittle, but not hard, and of a dull brownish black colour. It can then be easily pulverized.

3. Castor has a peculiar strong and somewhat disagreeable odour, and a bitter, pungent, aromatic, and persisting flavour. The odour of castor is so much stronger as it is fresher, but it loses much of its weight in drying; and therefore in buying castor that which, being dry, has much odour should be preferred. That which is tasteless and inodorous is good for nothing.

4. Two kinds of castor are met with in commerce, namely, the Russian, and the Canadian castor; the best comes from Russia or rather from Siberia, but that from Canada is now almost the only kind found in shops.

5. Formerly, castor was an exceedingly expensive article, and was in consequence adulterated to a very great extent. Now, however, its price is more moderate, but the adulterating practices, instead of having diminished, seem, on the contrary, to have augmented in proportion, as if to make up for a reduction in the profit. Not only is castor adulterated, but it is sometimes altogether counterfeited by means of dried blood mixed or kneaded with a gum, such as gum ammonia, with addition or not of a little real castor, the whole being put up in artificial bags. This fraud, however, is easily detected by comparing the spurious with the genuine castor, as follows:—

6. The bags which contain the genuine castor consist of two smaller bags filled with fat, having the odour of castor, or at any rate they present distinct traces of it at the place where they existed.

7. Genuine castor consists of several superposed membranes, the inner one of which presents, on its external surface, a great number of small silvery scales.

8. If the contents of the bags are examined the castor will be recognised as genuine, not only because a cavity

should then exist in the centre, but also because the castor should be enveloped in membranes to such an extent that it cannot be detached therefrom, either by water or by alcohol, except it be previously dried and broken.

9. In spurious castor, on the contrary, it will be found that the fat (or indications of its having existed) in the two smaller bags above mentioned, is wanting, and that the larger bag is bigger and rounder than that of the genuine article, and has been imitated with the scrotum of young goats, or the gall vesicle of the sheep; that the contents of the bags consist of a substance either soft or brittle, of a semitransparent red colour, having only a feeble odour of castoreum; that it easily dissolves in alcohol, and that it turns black when the solution of a persalt of iron is poured upon it, because generally the vegetable substance employed to adulterate it contains tannin.

10. In spurious castor no trace of the superposed membranes mentioned before are observable.

CASTOREUM.—See *Castor*.

CASTOR OIL.

OLEUM RICINI. OIL OF PALMA CHRISTI.

1. Castor oil is obtained from the seeds of the *ricinus communis*, or *palma Christi*, either by boiling the seeds first, and then subjecting them to pressure, or else by subjecting the seeds to the action of the press, without previous boiling, in which case, the oil thus produced is said to be *cold pressed*, and is much superior in quality, being sweeter and less liable to become rancid.

2. Cold expressed castor oil is almost colourless and of a slight fatty, cloying odour and flavour; it is more viscid than

any other oil, and is soluble in all proportions in highly rectified alcohol.

3. Formerly castor oil was very often adulterated with fixed oils; this fraud, however, owing to the cheapness of the article must now be very rare, at any rate it can be readily detected, for all fixed oils, being insoluble in pure alcohol, which, on the contrary, readily dissolves castor oil, the amount of the impurity may be at once estimated. This is done by pouring a certain quantity of the oil to be examined, in a graduated tube, and adding six or eight times its volume of pure highly rectified alcohol. The whole is then to be well shaken and afterwards left at rest. The alcohol, having dissolved the castor oil, leaves the fixed oil untouched, and its quantity may at once be estimated by the divisions of the graduated tube. It is absolutely necessary that the alcohol employed should be highly rectified, its gravity should not be more than 0.828.

4. When castor oil has been obtained by previously boiling the seeds in water, instead of being almost colourless, it has a brownish colour, which, however, is the case with that which has become rancid, no matter how obtained. The rancidity can be removed, it is said, by adding a little caustic magnesia, and boiling for about a quarter of an hour with water.

C A T E C H U.

TERRA JAPONICA. CUTCH.

1. Catechu is an extract prepared in various parts of India and Malabar, by inspissating an aqueous decoction of the fruits and wood of the *acacia catechu* and *uncaria Gambir*.

2. The catechu of *Bombay*, or *Bombay cutch*, is in square masses of two or three ounces weight, of a reddish brown

colour, brittle, of a uniform texture, and of a shining and uneven fracture, sp. gr. 1.39. It consists of—

Tannin	.	.	.	52
Extractive matter	.	.	.	34
Mucilage	.	.	.	7
Impurities	.	.	.	7
				100

3. *Bengal catechu*, or *cutch*, is in round and flat lumps, weighing from three to four ounces, of a rusty colour outside, and of a dark brown colour internally, more compact than the other varieties. It contains vegetable detritus; its fracture is dull, and its specific gravity is 1.28. It consists of—

Tannin	.	.	.	49.5
Extractive matter	.	.	.	36.5
Mucilage	.	.	.	7.0
Impurities	.	.	.	7.0
				100.0

4. *Malabar cutch* is also in amorphous masses, of a rusty colour outside, and internally of a dull, dark brown colour, brittle and gritty, and covered with leaves. Its specific gravity is 1.40. It consists of—

Tannin	.	.	.	45.8
Extractive matter	.	.	.	39.9
Mucilage	.	.	.	8.0
Impurities and sand	.	.	.	6.3
				100.0

5. Catechu is often adulterated by an admixture of various other astringent extracts, or by the incorporation of *sand*, *clay*, *ochre*, and other impurities. When, however, other extracts have been mixed with it, the catechu has a dark, almost black colour, and a shining appearance, and it some-

times feels glutinous or clammy. Moreover, the flavour, instead of being astringent, and then sweet and agreeable, is astringent and bitter. As catechu is entirely soluble, both in alcohol and in water ; the impurities, the sand, &c., may thus be readily separated.

6. There is another species of catechu which is manufactured in India, and which comes into this country, in the shape of cubic masses, about one inch in size, externally of the colour of catechu, though somewhat of a lighter hue, but internally, of a drab or greenish yellow colour, with a dull, granular fracture. It contains a very large proportion of starch, which may be separated by treating it successively with water and with alcohol. This species of catechu cannot evidently be mistaken for the genuine article, from which it differs in shape, in colour, size, and taste ; but samples have come under the examination of the author, which had undergone a certain roasting and steaming process, which had most materially altered that appearance, and rendered it singularly like genuine cutch ; the substance, after the above treatment, is almost entirely soluble in water, the starch having been converted into gum by the heat to which it has been submitted. In order to detect this fraud, the proportion of tannin contained in the suspected sample should be determined as follows :—

7. The catechu under examination must be first reduced to powder, put into a covered vessel, treated therein by boiling water, and the solution thus obtained, being filtered through a piece of linen, sulphuric acid should be poured in the filtrate, until it ceases to produce a precipitate. The precipitate thus formed must now be washed with acidified water, and then dissolved in boiling water. On cooling, a yellowish brown extractive matter falls down, which is to be separated by filtering. The liquor filtered therefrom has a reddish colour, and pulverized carbonate of lead is added thereto, until all the sulphuric acid is thrown

down as sulphate of baryta ; the carbonate of lead must be added so long as a precipitate or turbidness is produced, stirring the whole well. The liquor is then filtered, and the filtrate being evaporated *in vacuo*, the pure tannin is left in the form of a yellow transparent mass, readily soluble in water and in alcohol, which may then be weighed.

8. A more easy method of ascertaining the amount of tannin contained in the catechu under examination, consists in treating its solution in water by a solution of gelatine ; this produces a precipitate, which, being washed and dried at a steam heat until it ceases to lose weight, indicates the quantity of tannin. 100 grains of that dry precipitate contains 40 grains of tannin.

CAYENNE PEPPER.

CAPSICUM.

1. Genuine Cayenne pepper is made by pulverizing the pods of the *capsicum* or *Guinea pepper*. Cayenne pepper contains a white, shining, nacreous, very acrid substance, to which the name of *capsicine* has been given ; it is an alcaloid, pretty soluble in water ; it contains, besides, a red colouring matter, a little animal matter, mucilage, nitrate of potash, and other salts. The active principles of Cayenne pepper are soluble in water, in alcohol, and in ether.

2. Capenne pepper is often adulterated with *common salt*, finely pulverized *brick dust*, and, it is said, even with *red lead* !

3. These frauds may be readily detected by treating a portion of the sample with pure water, filtering, and testing the filtrate with solution of nitrate of silver. If a white curdy precipitate, or only a white turbidness appears, completely and immediately soluble in ammonia, and reprecipitated by

an excess of nitric acid, it is chloride of silver, and it indicates that *chloride of sodium* (common salt) is present. The precipitated chloride of silver is washed, dried, fused, and weighed. 144 of chloride of silver represent 60 grains of common salt.

4. The quantity of *common salt* may also be ascertained by means of a test solution of nitrate of silver, as described in the assay of silver, to which article the reader is referred.

5. The portion of the Cayenne pepper which remained in an insoluble state after treatment with water, should now be treated by acetic, or by nitric acid, and the whole thrown on a filter. A current of sulphuretted hydrogen must now be passed through the filtrate ; and if this produces a black precipitate, it is sulphuret of lead, and of course *red lead* was present. Or instead of a current of sulphuretted hydrogen, an excess of dilute sulphuric acid, mixed with alcohol, may be poured in the above filtrate, which will produce a white precipitate of sulphate of lead, which being collected on a filter and heated until the excess of sulphuric acid is expelled, may then be weighed. 144 of sulphate of lead represent 104 of lead.

6. The presence of *brick dust*, *ochre*, &c., may be ascertained by incinerating the portion which could not be dissolved by the acid ; the above inorganic impurities will, of course, be left behind.

Cayenne pepper should be burnt under the hood of a chimney, or in the open air, for the fumes of the oily and acrid resin which it contains, are exceedingly irritating, and induce violent coughing.

CEMENTS (HYDRAULIC).—See *Lime*.

CHEESE.

1. Cheese is manufactured from milk, by separating the curd from the whey, and subjecting it (the curd) to pressure.

2. There are, as everybody knows, a great variety of cheeses which need not be enumerated here; and, independently of the additions which are frequently made to the curd to impart the desired colour, cheeses are sometimes rendered unwholesome, or poisonous, by a peculiar kind of putrefaction which takes place under certain circumstances. In England cheese is coloured with Spanish annatto. Mr. Accum states that several instances came under his notice in which Gloucester cheese had been contaminated by red lead, and had caused serious accidents. And, more lately, serious accidents having been investigated, in which *red lead* was found in the cheese examined, and the eating of which had been productive of more or less severe illness, the poison was traced to an adulteration of the annatto employed to colour the cheese. The following case was first published by Mr. J. W. Wright, of Cambridge, in the Repository of Arts:—

“As a striking example of the extent to which adulterated articles of food may be unconsciously diffused, and of the consequent difficulty of detecting the real fabricators of them, it may not be uninteresting to relate the various steps by which the fraud of a poisonous adulteration of cheese was traced to its source.

“Several instances are on record that Gloucester and other cheeses have been found contaminated with red lead, and that this contamination has produced serious consequences. In the instance now alluded to, and probably in all other cases, the deleterious effect had been caused ignorantly, by the adul-

teration of the annatto employed for colouring the cheese. This substance, in the instance I relate, was found to contain a portion of red lead, a species of adulteration which subsequent experiments have shown to be by no means uncommon. Before I proceed further to trace this fraud to its source, I shall briefly relate the circumstance which gave rise to its detection.

“A gentleman, who had occasion to reside for some time in a city in the west of England, was one night seized with a distressing, but indescribable, pain in the region of the abdomen and of the stomach, accompanied with a feeling of tension which occasioned much restlessness, anxiety, and repugnance to food. He began to apprehend the access of an inflammatory disorder, but in twenty-four hours the symptoms entirely subsided.

“In four days afterwards he experienced an attack precisely similar, and he then recollected that having, on both occasions, arrived from the country late in the evening, he had ordered a plate of toasted Gloucester cheese, of which he had partaken heartily, a dish which, when at home, regularly served him for supper. He attributed his illness to the cheese. The circumstance was mentioned to the mistress of the inn, who expressed great surprise, as the cheese in question was not purchased from a country dealer, but from a highly respectable shop in London. He, therefore, ascribed the before-mentioned effects to some peculiarity in his constitution. A few days after he partook of the same cheese, and he had scarcely retired to rest, when a most violent cholic seized him, which lasted the whole night and part of the ensuing day. The cook was now directed henceforth not to serve up any toasted cheese, and he never again experienced those distressing symptoms.

“Whilst this matter was a subject of conversation in the house, a servant-maid mentioned that a kitten had been violently sick after having eaten the rind cut off from the cheese prepared for the gentleman's supper. The landlady, in con-

sequence of this statement, ordered the cheese to be examined by a chemist in the vicinity, who returned for answer that the cheese was contaminated with lead! So unexpected an answer arrested general attention, and more particularly as the suspected cheese had been served up for several other customers.

“Application was, therefore, made by the London dealer to the farmer who manufactured the cheese. He declared that he had bought the annatto of a mercantile traveller, who had supplied him and his neighbours for years with that commodity, without giving occasion to a single complaint. On subsequent inquiries through a circuitous channel, unnecessary to be detailed here at length, on the part of the manufacturer of the cheese, it was found that, as the supplies of annatto had been defective and of inferior quality, recourse had been had to the expedient of colouring the commodity with vermilion. Even this admixture could not be considered deleterious. But, on further application being made to the druggist who sold the article, the answer was, that the vermilion had been mixed with a portion of red lead, as frequently practised, on the supposition that the vermilion would be only used as a pigment for house-painting. Thus the druggist sold his vermilion, in the regular way of trade, adulterated with red lead to increase his profit, without any suspicion of the use to which it would be applied; and the purchaser who adulterated the annatto, presuming that the vermilion was genuine, had no hesitation in heightening the colour of his spurious annatto with that adjunct. Thus, through the circuitous and diversified operations of commerce, a portion of deadly poison may find admission into the necessaries of life, in a way which can attach no criminality to the parties through whose hands it has successively passed.

“Annatto is often contaminated with red lead, or a mixture of red lead and ochre, so that any cheese which might have been coloured by such annatto would be decidedly poisonous.

M. Mitchell says that he only met with cheese that contained lead on one occasion, although it may be comparatively common, as the matter with which it is coloured is very often adulterated with red lead."

3. According to Jules Garnier and Harel, in an article translated by Mr. Mitchel, cheese, in some parts of *Auvergne*, is also adulterated with potatoes boiled and mashed. There is nothing in this adulteration that is harmful to the animal economy; it is merely a simple fraud, and is, moreover, easily detected by boiling the suspected cheese in water, and treating the liquor, when cold, with solution of iodine, which will then impart the characteristic blue colour; indeed, in some parts of Saxony, potatoes in the above state are added to render cheese more nutritive.

4. Red lead in cheese is detected in the same manner as was described in the article on *Blanc Mange*, see page 90, § 41.

5. Cheese, however, is, under certain circumstances, very unwholesome even when it has not been adulterated, for it spontaneously undergoes changes which render it unfit for an article of food; indeed, most cheese has undergone a slight alteration of the kind I now allude to, and it is, I suspect, owing to this that cheese disagrees with so many persons; not because it is so especially indigestible, but because the peculiar matter the cheese contains in its altered state has much more action on some than on other persons.

6. The following case may not be uninteresting; it is related by Dr. Pollius, and extracted from Jules Garnier and Harel's work on the 'Falsifications of Food.'*

"Nine persons of both sexes became exceedingly ill after having partaken of some strong cheese; they were seized with distressing pains in the region of the heart and epigastrium, after which the symptoms extended over the whole of

* Des Falsifications des Substances Alimentaires, by Jules Garnier et Ch. Harel.

the abdomen. Violent vomitings in some, even of blood, supervened; then an abundant diarrhoea and severe cramps in the joints. Many were attacked with a shivering, which extended all over the body, alternately hot and cold, the extremities ice-cold; pulse small, frequent, and slightly hard; abdomen tense and very tender; or, on the other hand, much contracted. All the patients were troubled with vertigo, lassitude, anxiety, and thirst.

“Under the influence of suitable treatment, the patients recovered their health in a space of time varying from eight to twenty-four hours.

“The quantity of cheese consumed by each individual varied from $\frac{1}{8}$ th to $\frac{1}{2}$ ounce. The cheese had been prepared in the ordinary manner. It was soft, and of a uniform dullish-white colour, and some portions in their substance had a deeper tint and a firmer consistence than others; they exhaled a peculiar, disagreeable odour, and their taste was nauseous and acid; and lastly, neither mites, mouldiness, or other cryptogamic production could be detected.

“By boiling the cheese with water, the disagreeable smell became stronger, and the decoction, filtered and slightly concentrated by evaporation, became milky, and had an acid reaction. The cheese, by digestion with weak nitric acid, furnished a yellowish liquid. Dr. Pollius states that the poisonous effects produced by the cheese can be owing to nothing else but an acid caseate of ammonia, (?) and to an acidified fat. He isolated these two bodies, and prepared pills with them with bread crumbs, and gave them to mice, and one which had taken the pill containing the fat was seized with violent tremblings.

“According to Dr. Bruck, cheese can become poisonous under various circumstances, and this poisonous action is not the same with all persons, as I have already stated. Mr. Westrumb places the poisonous principle of cheese under the narcotico-acid class. Sertuerner, on analyzing this article of food, showed that it could undergo a chemical decomposition

giving rise to an essentially poisonous principle ; and Julia de Fontenelle and Witling thought that cheese, in its alteration, became impregnated with hydrocyanic (prussic) acid, and that it was owing to this substance that certain cheeses owed their poisonous effects."

CHICORY.—See *Coffee*.

CHILI SALTPETRE.—See *Nitre (Cubic)*.

CHLORATE OF POTASH.

OXYMURIATE OF POTASH.

1. The chlorate of potash met with in commerce is generally pure. Sometimes, however, it is contaminated by chloride of potassium. When pure it has a cooling, austere flavour, and its aqueous solution is not rendered turbid by nitrate of silver ; it is in the form of flat crystals of a nacreous appearance.

2. The solution of pure chlorate of potash is not rendered turbid by nitrate of silver, but if it contains any chloride of potassium, that re-agent immediately produces a precipitate of chloride of silver, soluble in ammonia.

3. For the purpose of determining the quantity of *chloride of potassium* contained in the chlorate under examination, the test-solution of nitrate of silver mentioned in the article on the assay of silver may be very conveniently employed. A given weight, 100 grains for example, of the chlorate should be dissolved in an adequate quantity of water, and the test-solution of nitrate of silver is poured from an alkalimeter into the solution of the chlorate, shaking or stirring it well after each addition of nitrate of silver ; the operator stops when the last drop of the solution of nitrate of silver

fails in producing a precipitate. The number of divisions employed indicates the quantity of chlorine, and consequently of chloride of potassium. 36 of chlorine represent 76 of chloride of potassium.

4. When chlorate of potash is contaminated by *chloride of potassium*, the best way of purifying it consists simply in dissolving it in boiling water. On cooling, the chlorate of potash crystallizes, whilst the chloride of potassium being much more soluble remains dissolved in the mother water.

CHLORIDE OF AMMONIUM.—See *Sal Amoniac*.

CHLORIDE OF BARIUM.

MURIATE OF BARYTES.

1. Chloride of barium is seldom impure, yet it is sometimes contaminated by *chloride of strontium*, or by *nitrate of strontia*, or by *perchloride of iron*, in which case it has a yellow tinge; it is also occasionally contaminated by *chloride of calcium*.

2. Pure chloride of barium crystallizes in four-sided, flat, transparent prisms, which decrepitate when heated, and are not altered by exposure; they have a very bitter, pungent, and nauseous flavour; their specific gravity is 2.825.

3. The presence of *strontia* is detected by digesting a portion of the salt in alcohol and inflaming it, in which case the alcohol will then burn with a characteristic red flame.

4. The presence of *perchloride of iron* is indicated by the blue precipitate produced by testing the solution of the salt with ferrocyanuret of potassium.

5. The presence of *chloride of calcium* is recognized first, because the salt is thereby rendered deliquescent; and by treating it with pure or absolute alcohol, the chloride of

calcium is dissolved, but the chloride of barium is untouched. The whole is then thrown on a filter in order to separate the chloride of barium, the filtrate which contains the chloride of calcium is evaporated to dryness at a gentle heat ; nitric acid is then added, and the liquor may now be tested for lime either by a mixture of sulphuric acid and alcohol, which will produce a precipitate of sulphate of lime insoluble in aqueous alcohol ; or after having neutralized the liquor by ammonia, the addition of oxalic acid produces a precipitate of oxalate of lime.

6. The solution of pure chloride of barium in distilled water should be perfectly clear and limpid, it should not be acted upon or rendered turbid by ammonia, by hydrosulphuret of ammonia, nor by sulphuretted hydrogen.

7. The addition of sulphuric acid should precipitate every fixed particle from it, so that after separating the sulphate of baryta thus produced, by filtering, the filtrate being evaporated in a platinum crucible should not leave the slightest residuum.

CHLORIDE OF LIME.

HYPOCHLORITE OF LIME. BLEACHING POWDER.

See Chlorimetry.

CHLORIDE OF SODIUM.

COMMON SALT. MURIATE OF SODA.

1. Common salt not being subject in this country to any fiscal tax, is exceedingly cheap, and accordingly is not adulterated, at least to any extent, the price of the article itself being as low, or nearly so, as that of the substances which might be employed for this culpable purpose.

2. Common salt, however, is often mixed with *water* in order to augment its weight, sometimes also it contains *sulphate* or *nitrate of lime* or *of magnesia*, or the *chlorides of these bases*.

3. In the countries where a tax is put on this commodity, the adulterating substances employed, besides those above named, are *sulphate of soda*, *alum*, *earthy matter*, &c. These impurities may be detected as follows :—

4. When salt has been moistened with water in order to augment its weight, its appearance sufficiently indicates the adulteration ; but in order to determine the quantity of the water, it is necessary to weigh a certain quantity of the salt, for example 1000 grains, previously reduced into fine powder, and expose it in a porcelain dish or capsule to the heat of a steam bath until the weight remains constant. The loss indicates the quantity of water, and if that quantity exceeds from 6 to 8 per cent, it is due either to a direct admixture of water, or to the presence of deliquescent salts.

5. *Sulphate of lime* is easily detected in common salt by its insolubility in water, especially if alcohol be added. The insoluble sulphate of lime may then be collected on a filter, washed with dilute alcohol, dried and weighed.

6. If *soluble sulphates* are present, a solution of chloride of barium will at once produce a precipitate of sulphate of baryta. For example : in order to detect the presence, and determine the amount of *sulphate of soda* in common salt, dissolve 1000 grains of the salt under examination in distilled water, filter the liquor, wash the filter, and add to the filtrate a solution of chloride of barium, until a precipitate is no longer produced. The whole is then left at rest, in order to allow the precipitated sulphate of baryta produced to settle. This being done, the clear supernatant liquor is decanted, and the precipitate is collected on a filter, washed thereon with boiling water, dried, ignited in a platinum crucible, and weighed. 117 of sulphate of baryta represent 40

of sulphuric acid, and, consequently, 72 of anhydrous sulphate of soda, or one equivalent of any other sulphate.

7. But as common salt often contains naturally a small quantity of *sulphate of soda*, which however does not exceed one per cent. in the average, it is only when the quantity exceeds that amount, that fraud may be suspected.

8. If any *soluble earthy salts* are present, a solution of carbonate of soda poured in the solution of the salt under examination, will produce a precipitate, the amount of which may be determined by weighing, after previously washing and drying it.

9. If the salt under examination contains any *carbonate*, its presence may be immediately detected by the effervescence which is produced upon pouring an acid (dilute muriatic acid for example) upon a portion of the salt. The proportion of the carbonate present may be determined in the manner described in the article on alkalimetry. (See *Alkalimetry*.)

10. 60 grains of pure salt should be exactly precipitated by 170 grains of nitrate of silver, and the precipitate so produced, being washed, dried, and carefully fused, should weigh 144 grains.

11. Chloride of sodium (common salt) may also be analyzed by means of the alkalimeter, with a test-liquor of nitrate of silver, as described in the article on the assay of the silver in the wet way. (See *Silver*.)

CHLORIMETRY.

1. Chlorimetry is the name given to the processes employed for ascertaining the strength or commercial value of substances containing chlorine, or from which chlorine may be produced. Chloride of lime, chloride of potash, chloride

of soda, and the ores of magnesia are the most important of these substances.

2. *Chloride of lime* (hypochlorite of lime) is a mixture of hypochlorite of lime, chloride of calcium, and hydrate of lime. ($\text{CaO}, \text{ClO} + \text{CaCl} + \text{CaO}, \text{HO}.$) It undergoes very great deterioration by exposure to the air, and may thus become perfectly valueless, for it gradually loses chlorine, and becomes converted into carbonate of lime. This deterioration is common to all other decolourizing chlorides, which are likewise decomposed by all acids, even by carbonic acid.

3. The value of chloride of lime depends altogether upon the quantity of chlorine which it contains, and which may be liberated. For technical purposes this estimation is exceedingly important, and should never be neglected by the bleacher.

Estimation by Sulphate of Indigo.

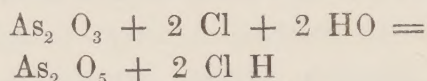
4. The process contrived by Gay Lussac is grounded upon the power which chlorine possesses of decolourizing indigo. For this purpose, a test-liquor is prepared, by dissolving a known quantity of sulphate of indigo in water, and pouring therein, drop by drop, a certain quantity of the sample of chloride of lime under examination, previously dissolved in a measured quantity of water. The solution of chloride of lime must be added, drop by drop, to the sulphate of indigo test-liquor, until the latter turns from blue to yellow, the operator taking care to stir the mixture without interruption. The principal objection to this method of chlorimetry is, that the test-liquor of indigo being always acted upon by light, which destroys a portion of the indigo, becomes altered in the course of time, even though it be kept in well-closed bottles and in the dark, and then ceases to yield accurate results.

Estimation by Arsenious Acid.

5. The process generally adopted now was contrived also by

M. Gay Lussac ; it is based on the power which arsenious acid ($\text{As}_2 \text{O}_3$) has of becoming peroxydized, that is, converted into arsenic acid ($\text{As}_2 \text{O}_5$) in the presence of chlorine and of water. This re-action is so rapid, that if organic substances capable of being decolourized by the action of chlorine are present whilst it is taking place, the colour is not destroyed so long as any portion of arsenious acid remains unconverted into arsenic acid ; but as soon as the last portion of the arsenious acid has been thus peroxydized, the liquor becomes instantly decolourized, which phenomenon at once indicates that the experiment is at an end.

6. This re-action may be represented by the following equation :—



That is to say, one equivalent of arsenious acid ($\text{As}_2 \text{O}_3$) in presence of two equivalents of chlorine (2Cl) and of two equivalents of water (2HO) produce one equivalent of arsenic acid ($\text{As}_2 \text{O}_5$) and two equivalents of hydrochloric acid (2ClH).

7. Taking the equivalent of arsenious acid = 100, and that of chlorine = 36, it is evident that 100 grains of arsenious acid will therefore correspond to 72 of chlorine ($36 \times 2 = 72$).

8. Dissolve therefore 100 grains of pure arsenious acid in about 4 fluid ounces of pure muriatic acid, free from sulphurous acid, and dilute the solution with water until on being poured into a 10,000 grains-measure-glass graduated, it occupies the volume of 7000 grains-measure marked on that glass. This being done, it is clear that each 1000 grains-measure of that liquor will contain nearly 14.29 grains of arsenious acid, corresponding to 10 grains of chlorine. This should be labelled arsenious acid test-liquor.

9. Having thus prepared a stock of arsenious acid test-

liquor, weigh off 100 grains from a fair average sample of the chloride of lime to be examined, and after tritulating them first with a little water in a glass mortar, and then adding more water, pour the whole into a flask, or glass vessel, capable of holding 2000 grains-measure, and marked with a scratch at that point. The mortar in which the chloride of lime has been trituated, must be rinsed with more water, and the rinsings poured into the 2000 grains-measure glass vessel just mentioned, until the whole of the 2000 grains-measure are filled up to the scratch. The whole must now be well shaken, in order to obtain a uniformly turbid solution, and half of it (namely, 1000 grains-measure) is transferred to an alkalimeter, which therefore will thus be filled up to 0° , and will contain 50 grains of the chloride of lime under examination ; and as the 1000 grains-measure of the alkalimeter are divided into 100 degrees, each degree or division will therefore contain 0.5, or half a grain of chloride of lime.

10. Pour also 1000 grains-measure of the arsenious acid test-liquor into a somewhat large glass-beaker, and add a few drops of solution of sulphate of indigo, in order to impart a distinct blue colour to it, shake the glass so as to give a circular movement to the liquid, and whilst it is whirling round, pour gradually into it the chloride of lime solution from the alkalimeter, watching attentively the moment when the blue tinge given to the arsenious acid test-liquor is destroyed. Care must be taken to stir the mixture well during the process, and to stop as soon as the decolorizing action takes place, which indicates that the whole of the arsenious acid is converted into arsenic acid, and that the process is finished.

11. The quantity of chlorine contained in the sample is determined in the following manner :—

1000 grains-measure of the arsenious acid test-liquor, in which the solution of chloride of lime was poured from the alkalimeter, contain 14.29 of arsenious acid, and repre-

sent, therefore, as we said, 10 grains of chlorine. (See No. 8.) And 1000 grains-measure of the solution of chloride of lime in the alkalimeter contain, as we said (No. 9), 50 grains of chloride of lime ; each degree or division of the alkalimeter contains therefore half a grain of chloride of lime.

12. Let us suppose now that, in order to destroy the blue colour of the 1000 grains-measure of the arsenious acid test-liquor, 90 volumes or divisions of the chloride of lime in the alkalimeter have been employed. These 90 divisions evidently contained the 10 grains of chlorine required to destroy the colour of the arsenious acid test-solution ; and since each division represents half a grain of chloride of lime, 45 grains of chloride of lime, containing 10 grains of chlorine, were present in the 90 divisions employed. If now 45 grains of the chloride of lime under examination contain 10 grains of chlorine, what is the per centage of chlorine in that same chloride ? The answer is 22.22.

$$45 : 10 :: 100 : x = 22.22$$

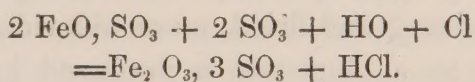
The chloride of lime submitted to the experiment contained therefore 22.22 per cent. of chlorine.

13. In this operation it is seen that, instead of pouring the test-liquor in the solution of the sample as in alkalimetry, it is, on the contrary, the solution of the sample which is poured into that of the test-liquor. It is necessary to operate in this manner, because otherwise the muriatic acid of the arsenious acid test-liquor would disengage at once a great portion of chlorine which would be lost, and render the result quite incorrect ; by pouring, on the contrary, the chloride of lime into the arsenious acid solution, the chlorine being disengaged in small portions at a time, meets always with an abundance of arsenious acid to re-act upon. It is better also to employ the turbid mixture of chloride of lime, than to allow it to settle, and to perform the experiment with the decanted portion.

14. Other substances may be substituted for arsenious acid, such as, for example, *sulphate of protoxyde of iron*, *ferrocyanuret of potassium*, and *subnitrate of mercury*, which have likewise the property of absorbing chlorine, and which, when properly managed, yield accurate results also.

Estimation by sulphate of protoxyde of iron.
(Runge's Method).

15. This method is based upon the rapid peroxydization which sulphate of protoxyde of iron undergoes, when in contact with chlorine in presence of water and of free sulphuric acid, two equivalents of the protosulphate being thereby converted into one equivalent of persulphate, on account of one equivalent of chlorine liberating one equivalent of oxygen from the water, which equivalent of oxygen adds itself to the protoxyde of iron, which becomes thus converted into peroxyde, and consequently into persulphate of iron, whilst the equivalent of hydrogen liberated forms with the chlorine one equivalent of hydrochloric acid, thus :—



By which it is seen that two equivalents of protosulphate of iron correspond to one equivalent of chlorine.

Taking the two equivalents of crystallized sulphate of protoxyde of iron ($2 \text{ FeO, SO}_3, \text{HO} + 6 \text{ HO}$) = 278.

And the equivalent of chlorine, as said before, at 36.

278 of protosulphate of iron will exactly represent 36 of chlorine.

16. Take therefore 278 grains of crystallized protosulphate of iron, perfectly clean, and previously dried by pressure between folds of blotting paper, or moistened with alcohol, and left to dry in the air until all odour of alcohol has disappeared, and dissolve these 278 grains of protosulphate of iron in water strongly acidified with sulphuric acid. Dilute this solution with water, so that it may occupy the volume of

3610 grains of water. 1000 grains-measure of this solution will therefore contain 77 grains of protosulphate of iron, and will accordingly correspond to 10 grains of chlorine. When only one experiment is contemplated, 77 grains of crystallized protosulphate of iron may be at once dissolved in water and acidified with sulphuric acid ; and this is the protosulphate of iron test-liquor.

17. Weigh now 100 grains of the chloride of lime under examination and dissolve them, as before mentioned, in a glass mortar with a sufficient quantity of water, so that it may occupy the bulk of 2000 grains measure of water, pour half of this, namely 1000 grains-measure, into an alkalimeter divided into 100 parts, each degree of which will therefore contain half a grain of chloride of lime. Pour gradually the chloride of lime from the alkalimeter into a precipitating glass containing 2000 grains-measure of the test-solution of protosulphate of iron above alluded to, stirring all the while, until it is completely converted into persulphate of iron, which may be ascertained by means of strips of paper previously dipped into a solution of red prussiate of potash (ferricyanuret of potassium), and dried, more chloride of lime being added as long as a blue stain is produced by touching the red prussiate of potash test-paper with a drop of the solution of protosulphate of iron.

18. The quantity of chlorine contained in the chloride of lime under examination is estimated as follows :—

Since 1000 grains-measure of the protosulphate of iron test-liquor, into which the solution of chloride of lime is poured, contains, as we said, 77 grains of protosulphate of iron, and correspond to 10 of chlorine ; and since, on the other hand, 1000 grains-measure of the solution of chloride of lime in the alkalimeter contain 50 grains of chloride of lime, that is, $\frac{1}{2}$ grain of that substance in each division of the alkalimeter ; let us suppose that the quantity of chloride of lime employed to peroxydize the iron of the 1000 grains-measure of protosulphate, amount to 90 divisions : it is evident that

the solution contained 45 grains of chloride of lime; and if these 45 grains of chloride of lime, contained the 10 grains of chlorine necessary to peroxydize the iron, 100 grains of the same chloride evidently contain 22.22 grains of chlorine. This calculation may be readily effected by dividing 1000 by half the number of the divisions poured from the alkalimeter; the half of 90 being 45, dividing 1000 by 45 is 22.22.

19. There are other methods of determining the amount of chlorine in chloride of lime, but the two experiments which we have related give the most accurate results, from the circumstance that the test-liquor of arsenious acid and of protosulphate of iron are not so liable to become altered as that employed in other processes.

20. The best way of preparing the protosulphate of iron for the experiment mentioned, consists in pouring dilute sulphuric acid upon clean iron nails, applying heat, filtering the hot solution, and adding about twice its own bulk of alcohol. The precipitate so produced is pure protosulphate of iron, which must be collected on a filter, washed with alcohol, and dried by exposure to the air on a sheet of blotting paper, until it no longer smells of alcohol. It must be kept in well-closed bottles, to prevent its becoming peroxydized.

21. In the Archives of Pharmacy, the following convenient test for chloride of lime is given :—

“ The properties indicated by copper, when acted on by sesquichloride of iron dissolved in hydrochloric acid, as stated by Fuchs, may be applied as a test for chloride of lime.

“ An accurately weighed quantity of chloride of lime is infused in water, and a solution of recently prepared simple chloride of iron then added in excess. No chlorine is evolved during this operation, but a quantity of oxyde of iron is formed exactly corresponding to the contents of chlorine—hydrochloric acid is then added in excess, a weighed piece of copper put into it and the liquor boiled, until its dark colour changes into a pale yellowish green, without further altera-

tion. The copper is then washed, dried, weighed, and the quantity of chlorine calculated from the loss of weight—64 of copper indicating 35.4 of chlorine. Such an experiment is executed in from one to two hours, and is best performed in a small retort, heated in a sand bath, with the neck arranged perpendicularly.”

CHLOROFORM.

1. Some years ago M. Dumas, in distilling chloral (a product of the action of dry chlorine upon anhydrous alcohol) with milk of lime, obtained, after due purification, a colourless, oily, volatile liquor, of an ethereal odour and of a fruity taste, resembling that of a bergamot pear, it is chloroform: which, at first looked upon as a substance of mere scientific importance, has since become an extensively manufactured article of commerce, as the best and most effectual anæsthenic agent.

2. It is to be deplored, however, that a substance of such value should be in many instances rendered positively dangerous, or even deadly, by carelessness in its manufacture, owing to which, impurities, which might otherwise be easily avoided or removed, are suffered to contaminate it sometimes to such an extent as to render it either ineffectual or poisonous.

3. Dr. Letheby, who carefully investigated the action of chloroform, says that in every case where the action of particular samples of chloroform was found to be irregular, some principle foreign to its true composition was detected. Among the principles most frequently met with were alcohol, aldehyde, free hydrochloric and hypochlorous acids, and some of the compounds of methyle. The latter, in his opinion, are exceedingly poisonous in their action, and he regrets that we have no ready means of discovering the

presence or of freeing chloroform from them. The others, however, are not so harmless as might be supposed. Chloroform containing only a small amount of alcohol, hypochlorous or hypochloric acid will create a good deal of irritation and a subsequent depression, foreign to the action of pure chloroform. The following is the mode of detecting these impurities which Dr. Letheby has adopted:—

“1. *Alcohol* is often recognized at once by the milkiness of the liquid. If it exists to the extent of from thirty to fifty per cent. (and I have often detected as much as this), the specific gravity of the sample falls much below 1.496; and when a drop of it is let fall into a little water, instead of sinking as a clear pellucid bead, it falls through the water as an opaque pearly drop. On shaking it in the water the mixture becomes milky, and it requires a long time for the chloroform to subside perfectly. After it has done so, it may be observed that the original bulk of the chloroform has diminished; in fact, the alcohol has been dissolved out of it, and it has shrunk accordingly. In this way we can often determine the amount of the alcohol present. Take, for example, about thirty drops of the suspected chloroform, put it into a narrow test-tube, mark the level at which the liquid stands, then add about two drachms of distilled water, and shake them well together. On allowing them to rest for an hour or so, the chloroform will collect at the bottom of the liquid, and we can then discover, from the diminution in its bulk, the amount of alcohol dissolved.”

Dr. Letheby thinks that much of the chloroform now used in America is contaminated with alcohol; for, according to the report of Professor Meigs, it has the low sp. gr. of 1.450; and he puts it whether this may not be one of the reasons for the unsatisfactory accounts which have come from that country.

“2. *Aldehyde* is another substance which may be occasionally met with in chloroform. It is recognized by its reducing action on the hydrated oxyde of silver, and by its

rendering a little liquor potassæ of a brown colour when it is heated with it. I am not sure that it occasions any injurious influence when it is inhaled with the chloroform, but it is likely to be converted into acetic acid, and this is somewhat of an irritant.

“ 3. *Hydrochloric acid* is a very common impurity of chloroform, and it often exists in it to a very considerable extent. A sample, which was furnished to the London Hospital a short time since, contained as much as fifty-three per cent of free hydrochloric acid—a quantity which, in its gaseous state, amounts to 500 per cent. of the bulk of the liquid chloroform. This sample, on attempting to use it, gave rise to the most distressing symptoms, occasioning cough, difficulty of breathing, a highly congested countenance, followed by rapid prostration of the vital powers, with almost complete collapse. If it had fallen into the hands of an inexperienced operator it would, without doubt, have produced fatal effects. Chloroform containing this acid has often an irritating odour. It reddens litmus paper, and gives rise to a white precipitate when it is shaken with a solution of nitrate of silver.

“ 4. *Hypochlorous acid* may be detected by its odour, by its reddening and then partially bleaching a piece of litmus paper, and by its giving a white precipitate with the solution of nitrate of silver.

“ 5. *Hydrochloric ether* may very often be recognized in chloroform. It is discovered by shaking the chloroform with water, then decanting the latter and distilling it from a water-bath. The odour of the hydrochloric ether is very evident in the portions which first come over.

“ 6. *Compounds of methyle*.—It is to be regretted that these dangerous compounds are not to be detected very easily. One of the best signs of their presence is the effect which they produce upon the animal system. They occasion a peculiar throbbing headache, and a rapid prostration of the vital powers. These effects may often be observed when the chloroform is only smelled for a little while ; and I have no

doubt that they are very frequently the cause of the discomfort which so often follows upon the use of certain samples of chloroform.

“ It is foreign to the object of this communication to point out the sources of these impurities ; but it may not be out of place to make a brief reference to a mode whereby they may be got rid of. Wash the chloroform three or four times with its own bulk of water, decant the water carefully after each operation, then introduce it into a retort with about four or five times its bulk of powdered quicklime, and carefully distil it by means of a water or steam-bath. The chloroform thus obtained will be generally quite pure ; and it should have the following properties :—

“ 1. It should be perfectly free from opacity.

“ 2. Its specific gravity should be near 1.496.

“ 3. It should neither redden nor bleach litmus paper.

“ 4. It should not become opaque when it is dropped into water.

“ 5. It should not occasion any whitening with a solution of nitrate of silver.

“ 6. It should not whiten or coagulate the white of egg.

“ The last two are very important tests, and they are easily applied. The white of egg should be used as it is obtained from the raw egg ; and a little of it, say as much in bulk as a pea, is to be dropped into the chloroform and allowed to remain there for an hour. If any alcohol is present it will whiten it.”

In addition to the above tests of the purity of chloroform M. Acar gives the following :—

7. Chloroform should not only be free from opacity, but it must be colourless also.

8. It should be completely soluble in alcohol and in sulphuric ether.

There is still another test which is recommended, but

from the observations of Kessler it appears not to be very trustworthy ; it is as follows :—

9. If a drop of chloroform be poured into a mixture, consisting of equal parts of concentrated sulphuric acid of specific gravity 1.847, and of water, which mixture, when cold, has a specific gravity of 1.440, it should fall to the bottom of the vessel. If it either floats, or remains suspended, it contains alcohol. Kessler has indicated a source of error ; he states, that a mixture of alcohol and of chloroform when dropped into the above test-liquor it separates, after stirring, into chloroform, which, on account of its being almost insoluble, remains at the bottom of the vessel, whilst, on the contrary, the alcohol is dissolved in the liquid above it. If, on the contrary, the liquid is not stirred, the drops may float on the surface, and the best chloroform may thus appear impure.

10. Pure chloroform is not inflammable ; if it can be inflamed, the presence of alcohol or ether may be suspected.

11. Chloroform has lately been employed by M. Dutremblay as a substitute for steam for working engines.

CHOCOLATE AND COCOA.

1. Chocolate is a preparation of the cocoa-nut, obtained by grinding the nuts, previously roasted and shelled, in an apparatus, which consists either of a flat stone with a steel cylinder, or of conical stone rollers revolving on a circular table of the same material, or of a mill of a peculiar construction. The mill, or the stones, are heated to about 212° Fahr., and the roasted and shelled cocoa-nuts are submitted with sugar to the grinding operation, by which they are reduced into a syrupy mass, which is received into moulds of various shapes, in which it hardens in cooling.

2. Besides cocoa-nuts and sugar, the manufacturer gene-

rally adds some arrow-root, many persons preferring the chocolate so prepared, because the oil or butter of cocoa is thereby rendered emulsive and more digestible. The preparation known as *cocoa-powder*, or chocolate-powder, when genuine, consists only of cocoa-nibs, sugar, and arrow-root, mixed and ground together, and then pulverized, by passing the mass through a grating-mill, and cooling it.

3. Chocolate, as well as cocoa-powder or flakes, prepared as above said, is one of the most grateful, nourishing, and easily digestible articles of food ; it belongs to the class of perfect alimentary substances. Unfortunately, however, many of the preparations of the cocoa-nut, sold under the name of chocolate, of cocoa flakes, and of chocolate powder, consist of a most disgusting mixture of bad or musty cocoa-nuts, with their shells, coarse sugar of the very lowest quality, ground with potato-starch, old sea-biscuits, coarse branny flour, animal fat (generally tallow, or even greaves). I have known cocoa-powder made of potato-starch, moistened with a decoction of cocoa-nut shells, and sweetened with treacle ; chocolate made with the same materials, with additions of tallow, and of ochre. I have also met with chocolate in which brick-dust, or red ochre had been introduced to the extent of 12 per cent. ; another sample contained 22 per cent. of peroxyde of iron, the rest being starch, cocoa-nuts with their shells, and tallow. Messrs. Jules Garnier and Harel assert, that cinnabar and red lead have been found in certain samples of chocolate, and that serious accidents had been caused by that diabolical adulteration.

4. Genuine chocolate is of a dark brown colour ; that which has been adulterated is generally redder, though this brighter hue is sometimes given to excellent chocolate, especially in Spain, by means of a little annotto. This addition is unobjectionable, provided the annotto is pure, which, however, is not always the case. (See *Annotto*.)

5. Genuine chocolate should dissolve in the mouth without grittiness, it should leave a peculiar sensation of fresh-

ness, and after boiling it with water, the emulsion should not form a jelly when cold ; if it does, starch or flour is present. The admixture of flour, or of starch, moreover, may be readily detected by the blue colour which is imparted to the decoction, after cooling, by solution of iodine.

6. *Brick dust* and other *earthy matters* are detected by incinerating a given weight of the chocolate or cocoa under examination ; the impurities remain among the ashes, and may be easily recognized. This adulteration is also readily detected by grating 500 grains of the chocolate in as fine a powder as possible, throwing it into about half a pint of cold water, stirring the whole briskly for about ten minutes, leaving it at rest for about two minutes, and decanting the supernatant liquor. The earthy matter will then have subsided, and will be left as sediment.

7. The presence of *animal fats* may be detected by the palate, for the chocolate generally has, in that case, a cheesy flavour ; or, when common butter, or oil has been added, it has a rancid flavour. This is quite characteristic, for butter of cocoa always remains perfectly sweet.

8. The presence of *animal fats*, or of *oils*, may also be recognized by saponifying a portion of the chocolate as follows :—Rasp about 2000 grains of the chocolate under examination, and boil them with water and some caustic potash. When the fat has saponified, dilute the mass with a sufficient quantity of water, and filter three or four times. The milky filtrate, which is in fact a solution of soap, should now be supersaturated with nitric acid ; this will separate the fat, which will float on the liquor after cooling. It may then be collected on a filter, and on rubbing a small portion of it between the fingers, the odour will generally indicate its origin ; but more effectually still, by heating it in a small capsule. Pure butter of cocoa has no odour.

9. Or the chocolate may be exhausted by sulphuric ether, and by evaporating it the fat will be left behind, and may then be identified as we just said.

10. If the chocolate has been mixed up with the *ground shells* of the cocoa-nut, the use of the microscope is the best way of detecting it. Or, after having treated a given portion of the chocolate by ether, the residuum may be exhausted by hot water, which will extract all the soluble portions and leave again a residuum, in which the sharp spiculæ of the ground husks, if any be present, may be readily seen with the help of a magnifying glass.

11. The presence of cocoa-nut shells in chocolate appears to be injurious to health. Dr. Ure relates in his Dictionary of Arts, Manufactures, and Mines, that samples of chocolate made at the Victualling Yard, Deptford, for the use of the Royal Navy, and manufactured by the Government Chocolate Mills, were sent to him for examination, by order of the Lords of the Admiralty, under the following circumstances :—

For sometime the chocolate, it would appear, had been distributed to sailors and convicts for their breakfast, at the rate of one ounce daily, when several of the men complained of its producing sickness, vomiting, purging, and other illness, and a few cases terminated fatally. A careful examination of the chocolate failed in detecting any impurity or deleterious substance, except that some gritty matter, incapable of mixing with water, and which, on closer examination, was found to consist of minute spiculæ of the cocoa-bean husks, which, when swallowed, became lodged in the villous coat of the stomach and bowels, where they created irritation and all the symptoms certified by several naval surgeons. It was obvious, observes Dr. Ure, that from the insoluble condition of the chocolate, it could be of little use as an article of food, or as a demulcent substitute for milk, and that, in fact, three fourths of it were, on this account, an ineffective article of diet, or were wasted.

12. In France, the chocolate paste has usually a little vanilla incorporated with it, and a considerable quantity of sugar, which varies from one third of its weight to equal

parts, and one pod of vanilla is said to be sufficient to flavour one pound and a half of chocolate. Pure, genuine chocolate improves in its flavour by keeping, which is the reverse with bad or adulterated chocolate, but the roasted beans soon lose their aroma if left exposed to the air.

CHROMATE OF LEAD.

CHROME YELLOW. COLOGNE YELLOW.

1. Chromate of lead is a fine yellow pigment, which, as found in commerce, is often adulterated with *sulphate of lead*, *sulphate of baryta*, *sulphate of lime*, sometimes to an enormous extent. *Carbonate of lead and of lime* have also been used for that purpose, but as on treating the chromate of lead, adulterated with the latter substances by an acid, an effervescence is immediately produced, betraying the presence of a carbonate, this fraud may be at once detected. This, however, is not the case with either sulphate of baryta, or of lead, or of lime, and these substances accordingly are almost exclusively employed for that purpose, especially sulphate of lime, which is said to render the yellow colour of the chromate more vivid and more mellow at the same time. The pigment sold under the name of *Coloyne yellow* consists of 25 parts of chromate of lead, 15 of sulphate of lead, and 60 of sulphate of lime.

2. The presence of *sulphate of lime* may be detected in the following manner:—a portion of the suspected chromate is first reduced to fine powder, and thoroughly mixed with one fourth of its weight of finely pulverized charcoal, and the whole is to be calcined in a covered crucible. Under this treatment the sulphate of lime, if any be present, will be converted into sulphuret of calcium, and on treating the residuum with dilute muriatic acid, a disengagement of sulphuretted

hydrogen will take place, easily recognizable by its odour (that of rotten eggs). The whole should then be thrown upon a filter, and to the filtrate, which has a green colour, ammonia is added, which will precipitate all except the lime. The whole is again thrown upon a filter, and if oxalate of ammonia be now poured into the filtrate, an abundant precipitate of oxalate of lime will be produced.

3. The analysis of chromate of lead may be performed as follows: having first reduced the chromate of lead into very fine powder, hydrochloric acid is poured upon it, and the whole is boiled, alcohol being added at the same time, in order to convert the chromate of lead into chloride of chromium which remains in solution, and into chloride of lead which remains in an insoluble state, along with any sulphate of lead, of lime, or of baryta which may be present. These insoluble substances are collected on a filter, washed with dilute spirits of wine, dried, and weighed. The filtrate which contains all the chloride of chromium is then boiled, and ammonia is poured into the hot liquor and heated with the ammonia, until the whole of the chromium is precipitated in the state of hydrate of oxyde of chromium; the supernatant liquor is then colourless. This hydrate is collected on a filter, washed, dried, and carefully ignited in a well-closed platinum crucible, and then weighed. 40 grains of oxyde of chromium = 52 of chromic acid, and, consequently, 164 grains of chromate of lead.

4. Supposing, therefore, the chromate of lead submitted to analysis to have been pure—since 164 grains of chromate of lead (PbO , $\text{C}_2 \text{O}_3$) contain

Oxyde of lead (PbO)	. .	112
+ Chromic acid ($\text{C}_2 \text{O}_3$)	. .	52
		164

The results obtained by the analysis of that quantity should be—

40 grains of sesquioxys of chromium precipitated by ammonia, corresponding to chromic acid . . .	52 grains.
140 grains of chloride of lead, insoluble in dilute alcohol, consisting	
Of lead	104
+ chlorine	36
	140

And corresponding to oxyde of lead (PbO) . . .

 112

Chromate of lead . . .

 164

Consequently, if the quantity of chromate of lead submitted to examination was, for example, 25 grains, the operator should obtain on the one hand

Sesquioxys of chromium . . .	6.09 grains
Chloride of lead	10.00 „

Or, in other words, each grain of chromate of lead operated upon should yield 0.24 grain of oxyde of chromium, and 0.4 grain of chloride of lead.

5. Before treating the chromate of lead by muriatic acid, as before said, it should be reduced into extremely fine powder by levigation; if this precaution be neglected, some portions may escape decomposition.

6. Chromate of lead has sometimes been adulterated with *starch*, but this fraud may be readily estimated by the loss which it sustains when strongly calcined in a crucible, an odour of burning vegetable matter being perceptible during the ignition.

CHROMATE OF POTASH.

1. Neutral chromate of potash is an important salt used for the preparation of all the other chromates, and especially that of lead. Pure chromate of potash crystallizes in regular rhomboedrons; but as it is an easily efflorescent salt, it often

forms a saline mass of a lemon-yellow colour. It has a bitter, disagreeable taste and is very soluble in water.

2. A salt is sometimes met with in commerce under the name of chromate of potash, but which is composed of 56.7 of sulphate of potash, and 43.3 of chromate of potash, This spurious article when in crystals may be at once recognized, because its crystals are in four or six-sided prisms, terminated by four or six-sided pyramids, whilst the pure chromate of potash is in regular rhomboedrons, without pyramids.

3. But when in efflorescent masses, this adulteration cannot be thus detected, and therefore it must be analyzed, which may be done as follows:—

4. A given weight, 50 grains for example, of the salt are to be dissolved in water, and a solution of nitrate of baryta is poured into the solution of the chromate until it no longer produces a precipitate. The precipitate so produced is yellowish white, and consists of chromate and of sulphate of baryta. By treating this precipitate with nitric acid, the chromate of baryta is redissolved, but not so the sulphate of baryta, which being insoluble both in acids and in water, may be collected on a filter, washed, dried and weighed. 117 grains of sulphate of baryta represent 40 grains of sulphuric acid, and consequently 88 grains of sulphate of potash.

5. If, on the other hand, the operator may wish to determine the quantity of the chromate of potash, he may do so by adding an excess of sulphuric acid to the liquor filtered from the sulphate of baryta, in order to precipitate the excess of baryta which exists in the solution, and after filtering the liquor, the oxide of chromium may then be precipitated by means of ammonia, collected on a filter, washed, dried, carefully ignited in a well-closed platinum crucible, and weighed. 40 grains of oxyde of chromium represent 52 grains of chromic acid, and consequently 100 grains of neutral chromate of potash.

6. Or the operator may at once proceed to estimate the quantity of chromate of potash in the suspected sample by dissolving a given weight of it in a small quantity of water, adding a pretty large proportion of muriatic acid with alcohol, applying heat until the whole of the alcohol has evaporated, after which the oxyde of chromium may then be precipitated by ammonia, filtered, washed, carefully ignited, and weighed.

CHROME IRON ORE.

CHROMATED IRON.

1. Chrome iron ore is a combination of oxyde of chromium with peroxyde of iron and alumina, in which the proportion of oxide of chromium varies from 39 to 53 per cent., that is in the well prepared ore, and this large proportion of oxyde of chromium renders it a highly valuable ore.

2. The analysis of chrome iron ore is made in the following manner:—

3. Take of the finely pulverized chrome-ore 200 grains, nitre 300 grains, mix well, and calcine in a covered hessian crucible at a white heat for two hours. Under this treatment the oxyde of chromium becomes converted into chromic acid, which combines with the potash of the nitrate, and forms chromate of potash. Reduce the crucible to coarse powder and digest it in boiling water, filter and supersaturate the liquid slightly with nitric acid.

4. To test the proportion of chromic acid or its equivalent of bichromate of potash, dissolve 1910 grains of acetate of lead in 10,000 grains-measure of water (about 20 liquid ounces-measure), and mark this, — “*Chrome test-liquor.*” 1000 grains-measure of this liquor correspond to 164 grains of chromate of lead, and 152 grains of bichromate of potash.

5. The test-liquor being prepared, 1000 grains-measure are put into an alkalimeter, and are to be gradually poured

into the solution of the chromate, slightly supersaturated with nitric acid, so long as a yellow precipitate continues to be formed.

6. The operator then reads off the number of divisions employed. Suppose, for example, that 50 divisions have been used, then, since 100 divisions (1000 grains-measure) represent 164 grains of chromate of lead, and 152 grains of bichromate of potash, then the 200 grains of chrome ore operated upon represent 82 grains of chromate of lead, and 76 of bichromate of potash.

7. Chrome iron ore may also be analyzed as follows :—

200 grains of the ore are to be finely pulverized and mixed with 300 grains of nitre, as in the preceding analysis, and fused in an iron crucible. After remaining exposed to a white heat for about two hours, the crucible is put into boiling water, until all that can be thus taken up has dissolved. The solution, which is strongly alkaline, is filtered, neutralized with acetic acid, and the alumina is precipitated by carbonate of ammonia ; it is collected on a filter, washed, dried, ignited, and weighed.

8. The filtrate which contains the chromic acid is boiled with hydrochloric acid, with an addition of a little alcohol, in order to convert it into oxyde of chromium, and after heating the whole until all the alcohol has evaporated, the oxyde of chromium is precipitated by ammonia, collected on a filter, washed, dried, ignited, and weighed.

9. The portion which refused to dissolve, when the crucible was treated by boiling water, consists almost entirely of peroxyde of iron.

10. Silliman's Journal for May, 1848, gives the description of another process for the analyzing of chrome iron ore, by M. T. T. Hunt, as follows :—

“The chrome iron ore is first to be very finely levigated, a gramme (about 15 gr.) of the washed ore will require 15 or 20 minutes' trituration in an agate mortar. It is then to

be mixed with ten or twelve times its weight of fused bisulphate of potash, and the mixture heated to fusion in a platinum crucible, and kept at a gentle red heat for about thirty minutes. The crucible and its contents when cold are placed in water, which, with the aid of heat, dissolves the saline mass. The greater part of the chromium is left as a green basic sulphate, insoluble in water or hydrochloric acid, and apparently identical with that obtained when any salts of chromium are heated with an excess of strong sulphuric acid.

“The best mode of treating this mixture of soluble and insoluble salts, is to boil the whole for a few minutes with an excess of potash or soda, which precipitates the alumina, iron, and chromium that may be in solution, and decomposes the insoluble sulphate; it is not easy, however, in this way to remove all the sulphuric acid, and thus render the residue quite soluble in hydrochloric acid; but this is of no importance. The dried precipitate is now to be treated after the process recommended by Fresenius, which consists in fusing it with five times its weight of a mixture of equal parts of nitre and carbonate of soda. The operation should be performed in a platinum or rather in a silver crucible, over a spirit lamp, and the mixture kept in fusion ten or fifteen minutes, to ensure the perfect solution of the chromium. The chromate of potash is then dissolved out from the mixture of oxyde of iron, alumina, and magnesia, which may be separated in the ordinary manner; if the precautions above mentioned have been observed, no trace of undecomposed ore will be left after treating the mixture with hydrochloric acid. A small portion of magnesia remains dissolved in the filtrate from the precipitate by carbonate of soda, and may be obtained by evaporating to dryness. Any silica which the mineral contained is also dissolved, and may be separated in the usual manner.

“The presence of a small portion of sulphates prevents the determination of the chromic acid by a salt of lead; we

accordingly supersaturate the solution with hydrochloric acid, and boil with alcohol to convert it into chloride of chromium, from which the oxyde is precipitated, by adding ammonia in excess and boiling for a few minutes.

“I have employed this method several times with perfect success. It is easy of execution, and, being free from any source of error, yields very accurate results.”

CHROME-YELLOW.—See *Chromate of Lead*.

CHRYSOCAL.—See *Brass*.

CHRYSOCOLLA.—See *Borax*.

CINNABAR.—See *Vermillion*.

CITRIC ACID.

1. Citric acid is colourless and crystallizes in rhomboedral prisms, very soluble in water, and of a very sour flavour. It is not altered by exposure to the air, it is now manufactured in large quantities for the use of calico printers. Its specific gravity is 1.034. The aqueous solution of citric acid is speedily altered by exposure.

2. Citric acid is sometimes adulterated with *tartaric acid*. In order to detect this fraud it is customary to dissolve a given weight of the acid in water, and to add gradually thereto a solution of hydrate or of carbonate of potash, stirring the whole briskly, which produces a precipitate of bitartrate of potash. If, however, the quantity of tartaric acid present is small, these re-agents may fail in indicating it, because bitartrate of potash is readily soluble in a slight excess of

hydrate, or of carbonate of potash. It is therefore better to employ a saturated solution (in the cold) of chloride of potassium, or of nitrate of potash, or of neutral sulphate of potash, an excess of which does not interfere with the precipitate of bitartrate of potash, which will be formed if tartaric acid is present. It should be remembered that bitartrate of potash is not an insoluble, but only a sparingly soluble salt, and therefore the solution of citric acid should not be dilute, for no precipitate would then appear.

3. If, however, the solution of citric acid is already dilute it should be concentrated by evaporation, or, instead of the above named salts of potash, acetate of potash may be used in preference, for being a deliquescent salt, it need not be dissolved previous to adding it to the solution of the citric acid.

4. Citric acid sometimes attracts moisture by exposure, which is a proof that it still retains a small proportion of the sulphuric acid used to prepare it, and the presence of which may besides be detected by dissolving a portion of it in water, and testing with a solution of chloride of barium, which will, in that case, produce a white precipitate of sulphate of baryta insoluble in water, and in hydrochloric acid. In order to free it from this sulphuric acid, it should be recrystallized several times.

CLAY IRON STONE.—See *Iron Ores*.

CLOVES.

1. Cloves are the flowers of the *caryophyllus aromaticus*, growing in the Moluccas, and gathered before their opening or development. Good cloves have a strong, aromatic odour, and should be large, plump, and of a dark brown, nearly black colour; they should not be broken or otherwise im-

perfect, the knob at the top should be present, and when pressed with the nail, the oil should exude.

2. Cloves are often adulterated by subtraction: that is to say, cloves from which the essential oil has been extracted, are sometimes mixed with other genuine cloves of good quality, from which they reabsorb a portion of the essential oil which the latter contain, so that the fraud cannot be easily detected, except by careful examination, for the cloves from which the oil has been extracted are of a lighter colour, they generally have lost the knob at the top, are less heavy, and when they are pressed by the nail no oil exudes.

3. As cloves readily absorb moisture, their weight may be considerably increased by putting them in a damp place. This fraud is readily detected by weighing off a certain portion of the sample, and placing it under a glass receiver, by the side of a wide capsule filled with concentrated sulphuric acid. On re-weighing it, the loss indicates the amount of water.

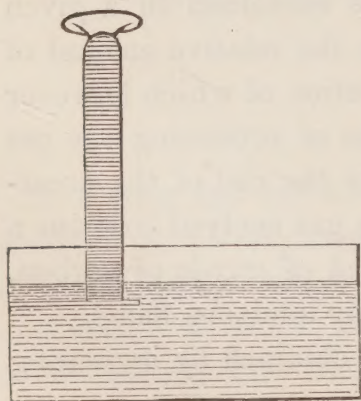
COAL GAS.

1. The coal gas used for gas-light is a mixture of carbonic acid, carbonic oxyde, hydrogen, and nitrogen, protocarburetted hydrogen, with vapours of hydrocarbons and olefiant gas; the illuminating power of the gas depends chiefly upon the quantity of the two latter substances contained in a given bulk of gas, but more especially upon the relative amount of the last named compound, the proportion of which however diminishes gradually as the operation of producing the gas at the works advances, until towards the end of the treatment of the charge in the retorts, the gas evolved contains a considerable quantity of hydrogen and of oxyde of carbon, which burn with a faint blue and dimly luminous flame.

2. The same unfavourable result is obtained by increasing

the heat of the retorts containing the charge of coals, the gas being thereby decomposed or decarbonized. But whilst the illuminating power of the gas evolved by such treatment is deteriorated, its *volume* or quantity is unfortunately increased. We say *unfortunately*, because gas being paid for by gas-meter registering, it is evident that the customer often, and to a great extent, is not in reality supplied with that for which he contracted with the company, and he therefore pays, not for lighting gas, but for its ghost. I have noticed that the gas supplied during the first part of the evening is generally of sufficiently good quality, but between ten and eleven o'clock, its illuminating power suddenly changes and almost vanishes, gas of an inferior quality being probably at that time turned on.

3. Since chlorine has the power to form, by combining with olefiant gas and with the vapours of hydrocarbon, a peculiar oily liquid, the production of which is proportionate to the quantity of the above substances which may be present in the gas, it is clear that the diminution which a given volume of gas will suffer, after being mixed with chlorine, will at once give the amount of olefiant gas and of hydrocarbon vapour contained in that volume, and, consequently, indicate its illuminating power. This is easily done by filling a graduated jar, of about an inch in diameter, with water, and then turning it upside down in a water-trough, so that being filled with water, it may stand in the trough in the following manner:—



Transfer now the gas to be examined to the graduated jar until it is half full, and fill the other half of the graduated jar with pure chlorine gas, carefully protecting the mixture from solar light. Leave then the whole at rest for twenty-four hours, and then observe the amount of con-

densation which will have taken place. The diminution of the volume of the gas first introduced into the jar will indicate very approximatively the proportion of olefiant gas in that volume.

4. For practical purposes the value or illuminating power of coal gas may be readily estimated by comparing the shadows projected upon a screen, such as a sheet of white paper, by the interposition of an opaque body between a wax candle, or any other flame, taken as a standard, and the jet of inflamed gas to be tested, and with which it has to be compared. The experiment is performed as follows :—

5. A sheet of unglazed white paper is to be pinned smoothly to a wall before the two lights whose relative illuminating power has to be tested, and between them and the sheet or screen of white paper, and at a distance of about three inches from the latter, an iron rod, about the size of the small finger, is to be placed, taking care to dispose the lights in such a way that the two shadows of the rod upon the screen be contiguous. The rod should be previously blackened by holding it in the flame of a candle. If the two shadows are not of the same depth, or degree of blackness, one or the other of the two lights must be shifted towards the screen, or removed at a greater distance from it, until looking at the two shadows, by standing exactly opposite the paper screen, they appear to have the same degree of intensity. This point being hit, the relative intensity of the lights being directly as the square of their distance from the screen, their comparative illuminating power becomes known. Suppose, for example, that the jet of inflamed gas being at a distance of three feet from the screen, it is found that the wax candle requires to be moved towards the screen, at a distance of two feet therefrom, to obtain the same depth of shadow, the operator has only to square these numbers, and the difference expresses the proportion :

$$3 \times 3 = 9; 2 \times 2 = 4$$

The relative illuminating power of the two flames would then be in that case as 4 is to 9, or as 1 is to $2\frac{1}{4}$. The flames to be compared should be placed at the same height.

6. In order to ascertain whether coal gas is free from sulphuretted hydrogen, a moistened strip of paper impregnated with a solution of acetate of lead, should be held up to the gas-burner whilst the gas is escaping. If the latter is pure, the above test-paper will remain colourless, but it will turn black if the gas contains sulphuretted hydrogen.

ARRANGEMENT OF GAS METERS.

7. A correspondent of the "Builder" says :—"In supplying the wet meter with water, some care should be exercised. The suppliers are safer than the consumers. As soon as the water decreases in such quantity as would allow more gas to pass than would be registered, directly does a valve (until then kept open by a float) close, to prevent the passage, and darkness ensues, until additional water be supplied to the meter. This is all very admirable for the security of the companies, but if there be too much water, i. e. more than actually required, the consumer does not then obtain the proper quantity of gas; but there is a limit to this in what is termed the dry-well, into which, if the water should be in such excess as to flow, the consumer has notice by the flickering or jumping of the several lights. Now, it is between these two extremes—the want and the excess of water—that the consumer's attention should be directed, and by the insertion of a piece of plate-glass in the front of the meter, the quantity of water may be ascertained at a glance, at any time, and be kept at a fair height (to a mark), and so a fair quantity of gas measured. Perhaps it will be as well to say that this can only be done, without leave, where the meter belongs to the consumer."

COBALT ORE.

GREY COBALT ORE. ARSENIO-SULPHURET OF
COBALT.

1. Cobalt is found principally in the following minerals:—

Oxygenated Ores. —Oxyde of Cobalt.

Cobaltiferous manganese.

Sulphuretted Ores.—Sulphuret of Cobalt.

Sulphate of Cobalt.

Arsenietted Ores. —Arseniuret of Cobalt.

Arsenio-sulphuret of Cobalt.

Arsenate of Cobalt.

Arsenite of Cobalt.

2. Of all these ores the arsenio-sulphuret, or grey cobalt, is the richest, and, consequently, the most valuable. It consists of equal equivalents of biarseniuret and of bisulphuret of cobalt; its formula is therefore $\text{Co As}_2, \text{CoS}_2$. In appearance it is very much like the arseniuret of cobalt, but as it is almost free from nickel, it is much more easily analyzed than the arseniurets, which are always found mixed with arseniurets and sulphurets of iron and of nickel, which cannot be accurately separated, especially the nickel, except by a peculiar process which is kept secret.

3. In the course of the elaborate investigations which I undertook in reference to the manufacture of oxyde of cobalt, I tried most of the various methods of analysis of cobalt ores which have been published, and I am satisfied that when both cobalt and nickel are present in the ore, they cannot be separated from each other by any of those methods, even with moderate accuracy. By Liebig's method a per-

fectly pure oxyde of cobalt can be obtained, it is true, but a great quantity of the cobalt contained in the ore remains behind, and, if the operator attempts to obtain the whole of it, it is then contaminated by either oxyde of nickel, or of iron, or by both.

3. Liebig's process is as follows :—The ore is first pulverized and roasted, and then projected by small portions at a time, into a small crucible or iron vessel containing three parts of bisulphate of potash, fused by a moderate heat, and which from being fluid at first, soon after the addition of the pulverised ore becomes of a pasty consistence. The fire is then urged, until the mass, being perfectly fused, emits white fumes of sulphuric acid no longer. The fused mass is then withdrawn from the crucible, and when cold, it is reduced to powder, and boiled (*in an iron boiler*) with water, to separate the soluble matter ; the liquor is then filtered, or decanted clear. It should be of a pink colour, and should yield, with pure potash, a blue precipitate of hydrated oxyde of cobalt, which must be washed with boiling water. This process is based upon the property of sulphate of cobalt to resist a red heat without undergoing decomposition, whilst the sulphates of iron and of nickel are decomposed at that temperature, and remain behind in an insoluble state. I have, however, tried this process in every imaginable way, treating the ore, as described, both in iron and in clay crucibles (the first are the worst) with bisulphate of potash and with sulphuric acid ; but without success. I invariably found, that if, in order to obtain all the cobalt present in the ore, the temperature was not urged to the highest point, but kept for about one hour at a good red heat, a portion of the sulphate of iron and of nickel resisted decomposition, and the liquor obtained in treating the residuum with boiling water had a colour which may appear pink to the unpractised eye, but which, in reality, has a murky tinge, and is far from the beautiful and deep rose colour, which is one of the characteristics of the solution of pure cobalt.

5. I would remark, that all cobalt solutions, when much diluted with water, always appear of a beautiful pink colour ; but let the operator concentrate the solution by evaporation, and he will soon perceive, that, as it gradually becomes reduced in bulk, the colour will become deteriorated, and ultimately turn brownish or orange, which is not the case with the solution of the pure oxyde of cobalt.

6. The solution of sulphate of cobalt is that which may most deceive the operator, because it has always a fine colour, even when exceedingly impure ; and an incompetent person may thus flatter himself that he has at last succeeded in obtaining *the pure solution* sought after, when he may find that the oxyde thrown down from such a liquor may be contaminated to an enormous extent. A sample of oxyde of cobalt, which had been represented as *pure*, and which was sent to me for analysis, I found to contain no less than upwards of 70 per cent. of oxyde of iron and other impurities.

7. If, however, instead of exposing the mass fused with bisulphate of potash, as above said, to a good red heat only, the temperature is raised to a good white heat, and kept to that point for about one hour, the mass after cooling and being treated with boiling water, yields a beautiful pink solution of sulphate of cobalt ; but this is attended with great loss, because a large quantity (nearly one half) of the sulphate of cobalt is decomposed at that heat, and remains in the insoluble residuum.

8. Another criterion of the purity of oxyde of cobalt is this :—If a portion be treated by concentrated hydrochloric acid, it should yield a solution (without any residuum) of a magnificent blue colour, similar to that of copper in ammonia ; if it has the slightest tinge of green, nickel, or iron, or both nickel and iron are present. This blue solution, diluted with water should immediately become of a pure, bright, and deep rose colour, and a solution of pure caustic potash should re-precipitate the cobalt in the state of a hydrate, in fine blue flakes, without effervescence, and these should be converted

by ignition, at a low red heat, into a fine black powder. When oxyde of cobalt fails in one of these characteristics, it may be confidently declared impure.

9. The processes described by Mr. Louyet, in the "Chemical Times," in the "Chemical Gazette," in the "Bulletin de l'Académie de Belgique," and in the "Philosophical Magazine," in the months of December, April, and August, 1849, are perfectly incorrect, and should not be relied upon in the slightest degree.

"Hæc nobis dixit per jocum."—PLAUT.

10. The constituents of grey cobalt ore free from nickel are as follows :—

	Skutterud.	Tunaberg.	Tunaberg.
Cobalt .	33.10	33.66	44.00
Arsenic .	43.47	49.00	55.00
Sulphur .	20.08	6.66	0.50
Iron . .	3.23	5.66	0.00
	100.00	97.98	99.50
	Stromeyer.	Tessaret.	Klaproth.

11. As grey cobalt is insoluble in hydrochloric acid and in sulphuric acid, aqua regia must be employed to dissolve it, and the analysis may be performed as follows :—

12. Take 100 grains of the ore, previously well pulverized, and digest them in a flask with strong nitric acid ; when the action of the acid has nearly ceased, concentrated hydrochloric acid should be added, and the whole boiled until the sulphur separates in perfectly yellow lumps. To obtain these, it is sometimes necessary to evaporate the liquor to a somewhat pasty consistence. Water is then to be added, and the lumps of sulphur (and the silica, if any be present, which is generally the case) should be separated by filtering. A stream of sulphuretted hydrogen should now be passed through the filtered

liquor, for a long time, that is, until it is fully supersaturated, and smells strongly of sulphuretted hydrogen, after which, it must be left to digest for several hours, at a gentle heat, in order that all the sulphuret of arsenic may completely separate.

13. The solution filtered from the sulphuret of arsenic contains now the cobalt and the iron, which may be separated from each other as follows:—

14. A stream of chlorine is first passed through the liquor filtered from the sulphuret of arsenic, in order to convert the iron, which has been deoxydized by the action of sulphuretted hydrogen, into peroxyde of iron, or else the liquor should be concentrated by evaporation (if too dilute), and, a little nitric acid being added, the whole should be boiled. The solution should next be nearly saturated with ammonia, that is to say, ammonia must be carefully added, stirring all the while, until a few reddish-brown flakes of peroxyde of iron begin to appear. The whole is heated in order to see whether these flakes will redissolve; if they do, more ammonia must be poured in: but should too much ammonia have been incautiously added, it may be easily remedied by pouring a few drops of dilute hydrochloric acid. The solution having been nearly saturated, as just said, with ammonia, a solution of neutral succinate of ammonia is added in excess, which will precipitate the iron in the state of persuccinate of iron. The whole is then left at rest in a warm place, for some time, after which the liquor is allowed to cool, and the persuccinate of iron is separated by filtering, washed, dried, ignited, and then weighed as peroxyde of iron.

15. The liquor filtered from the precipitated persuccinate of iron is now treated by hydrosulphuret of ammonia, which precipitates the cobalt in the state of sulphuret of cobalt (black). This precipitate is collected on a filter, and washed with water containing a little hydrosulphuret of ammonia. After washing, the sulphuret of cobalt may be scraped as completely as possible from the filter and put into a glass-

beaker, the filter is then burnt on the cover of the crucible, (not *in* the crucible, which might otherwise be damaged by the reduction of a little oxyde of cobalt to the metallic state, by the charcoal of the filter). It is easier and quicker to burst a hole in the filter, and by means of a thin stream of water from the washing bottle, to wash the contents of the filter down through the hole into the glass-beaker, which will supersede the necessity of burning the filter. The supernatant water may now be carefully decanted, and strong nitric acid being poured on the sulphuret of cobalt in the beaker, the whole is digested with the help of heat, until the cobalt has dissolved, and the sulphur has agglomerated into lumps of a perfectly yellow colour, which may then be separated by filtering. Before filtering the liquor it should be diluted with water, for otherwise it would corrode the filter and pass through. The filtrate is then treated by a solution of pure potash which precipitates the oxyde of cobalt (blue). This blue precipitate of hydrated oxyde of cobalt is then collected on a filter, washed with boiling water, ignited and weighed, which, for practical purposes, gives a sufficiently accurate result; but if great accuracy is required, the ignited oxide of cobalt must be reduced to the state of metallic cobalt by heating it in a stream of hydrogen gas. (See my edition of Rose's Treatise of Analytical Chemistry, vol. II, page 128.)

See the article on *Zaffre*.

COCHENEAL.

1. Cochineal is a small insect which, as met with in commerce, has the appearance of small berries or seeds of a dark brown or purple colour, shrivelled and marked with little transversal furrows or wrinkles; sometimes cocheneal is

superficially white, in which case it is known as *silver cocheneal*, the other being called black cocheneal.

2. Dr. Bancroft says that that cocheneal is best which is large, plump, dry, and of a *silver white* colour on the surface, but this appearance is often artificially given, according to Dr. Ure, by moistening the genuine cocheneal with gum water, and then shaking it about in a bag or box containing pulverized sulphate of baryta, by which the appearance of silver cocheneal is at once imparted, the weight of this expensive article being thus increased to the extent of 10 or 12 per cent. with worthless heavy spar, which is then sold at the price of cocheneal.

3. Pulverized *salt* and *carbonate of lead*, *Venice talc* and *steatite*, are often used in the same manner to imitate silver cocheneal.

4. All these falsifications may be detected by macerating the cocheneal in water, the pulverized substances become loose, and may then be easily separated by decanting the turbid liquor and allowing to settle.

5. In order however to determine the tinctorial power of cocheneal, the operator should take 20 grains of the sample of cocheneal under examination, and also 20 grains of a sample of cocheneal known to be genuine, and both should be boiled separately in a quart of water for the same space of time, each decoction is thrown upon a separate filter, and the liquors are poured into two glass-measures capable of holding a quart, water is then added to each so as to make up the quart. An equal quantity of each of these liquors being now poured into the tubes of the colorimeter, (see *Indigo*,) the difference of colour may be ascertained and estimated from the proportion of water which must be added to the deeper solution to bring it to the same hue.

6. Or else, an equal portion of each of the two decoctions may be poured into two graduated tubes, and then an aqueous solution of chlorine is added, until the liquor becomes yellow. The difference in the quantity of the chlorine solution

employed to decolourise each liquor, indicates of course the difference in the quality of the cocheneal.

COCOA.—See *Chocolate*.

COFFEE.

1. The principal species of coffee are the Mocha or Turkey coffee, Jamaica, St. Domingo, Cuba and Porto Rico, Berbice, Demerara, Bourbon, Martinico, and Hayti. All species of coffee improve by keeping ; coffee is in the best condition when two or three years old.

2. The physical characteristics of coffee are the following. The beans or berries should be of middle size, soft and rounded, of a greenish colour, free from impurities, and they should not have the slightest odour of mouldiness, or any other odour, for the berries of coffee absorb most readily the effluvia from other bodies, and thus acquire an unpleasant flavour. Many cargoes of coffee have been spoiled from having been shipped with, or even put into vessels which had previously been freighted with sugar. A few bags of pepper are sufficient to spoil a whole ship-load of coffee.

3. Coffee, even that of the very best quality, and in the best condition, may be impaired by improper roasting, which operation is one of some nicety, and seldom well performed. If roasted too little, the aroma of the coffee will not be fully developed, and the best coffee may then yield a vapid or effete infusion, of a *green* flavour ; if roasted too much, the aroma of the coffee is dissipated, and the infusion will have a flat, bitter taste.

4. Coffee, after being roasted to the proper degree, should be emptied whilst hot in wooden boxes, furnished with sound

and well-fitting covers, and it should be kept therein until cold, and not emptied in an open hurdle, to which a see-saw motion is given in order to cool it rapidly as done in England. If roasted in small quantities, it may be emptied in a sheet of brown paper, and the whole wrapped up in a blanket of flannel until cold, the same sheet of brown paper being kept for that purpose.

5. Roasted coffee should be preserved in well-closed and perfectly dry vessels. The berries when properly roasted are of a full and rich brown colour, bright and oily superficially.

6. Coffee in grains, that is, unground, may be of inferior quality, or it may have been spoiled by contact with other substances, as we said, or damaged by sea-water, but as the berry itself cannot be adulterated, damaged coffee can be directly detected, merely by smelling or chewing a few of the beans. But when ground, the case is different, and coffee may then be, and in fact *is*, adulterated to an enormous extent, by an admixture of pulverized plants or roots previously roasted, such as *succory* or *chicory root*, (*cichorium intybus* of Linnæus,) *beet root*, *carrot*, *parsnip*, *madder root*, *roasted beans*, *peas*, *corn*, &c. Ground coffee offers, in fact, such a temptation to fraudulent admixture, that no one should buy ground coffee, except from dealers of first respectability, but of these we may say with Virgilius,

“ Apparent rari nantes in gurgite vasto.”—

And even then it is much better *for the consumer* to purchase a coffee mill, and to have his coffee ground at home; the expenditure of a few shillings will thus shelter him from all chance of fraud, and secure to him an infusion of coffee of an improved flavour, since ground coffee, even when genuine, gradually loses its aroma by keeping.

7. Of all the adulterations of ground coffee, that with chicory is the most prevalent. Whether the admixture of chicory with coffee in the proportions of one or two ounces of chicory to the pound of coffee, gives *body* and *depth* of

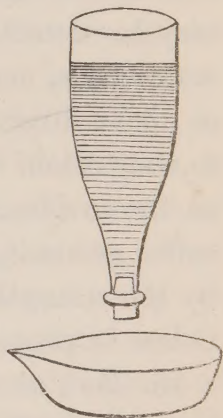
colour is a point which cannot be disputed ; it *does* give *body* and *depth* of colour, but this is a quality of a questionable nature, and one which, certainly, no exercised palate will relish. At any rate, when it is considered that the chicory itself may be purchased separately, and at a much lower price, of course, than coffee, we would advise the consumer to buy his coffee *unground*, and to add thereto whatever proportion of chicory may suit his taste.

8. With respect to the medicinal properties of chicory, which are said to be such as to *improve* those of the coffee, and to modify its stimulating action ; if it does so, it cannot be otherwise than by dilution, and those who, on that account, consider the addition not only as unobjectionable but as proper, should on the same ground allow the grocer to mix hay, or straw, or bran, with his tea, with a sprinkling of extract of logwood, and the publican to add water to his beer and spirits, the whole out of pure regard to the health of the customer, and merely to correct or modify the stimulating action of these goods. Chicory has no other virtue than that of imparting a brown colour to the water in which it is boiled or infused, of giving, at the same time to the liquid, a flat, sweetish, bitter taste, and of *being much less expensive than coffee* ; water, in reference to beer and spirits, possesses the last quality in an eminent degree, and if used (would it were so) by the publican to the same extent as the chicory by the grocer, there would be no drunkards.

9. However this may be, the adulteration of coffee by chicory, may be detected in the following manner :—

10. As the roots of chicory after having been kiln-dried, roasted and ground, resemble ground coffee so closely as to defy detection when mixed with it, it becomes altogether impossible to detect its presence by the eye alone. But, if a little of the suspected coffee be first moistened, and then rolled between the fingers, it will, if in any quantity, form a little pellet or ball, whilst pure coffee treated in the same manner cannot be agglomerated and remains in powder.

11. The presence of chicory may also be detected by throwing a portion of the suspected coffee into a glass of water, without stirring; the coffee remains for a while floating on the surface, but the ground chicory absorbs the water immediately, and falls to the bottom of the vessel, imparting a yellowish or brownish yellow colour to the liquor. If the coffee under examination, instead of being thrown into a tumbler, is put into an inverted bottle from which the bottom has been removed, or into a funnel, the chicory which falls down first may be at once separated, by adroitly removing the cork, and collecting the chicory in any convenient vessel placed underneath, after which it may be easily identified by its taste and pastiness.



12. When, instead of chicory, roasted corn, peas, or beans, are employed, the operator may detect the fraud, by first making an infusion of the suspected coffee, decolourizing it as much as possible by means of animal charcoal, and testing the *cold* liquor with an aqueous, or an alcoholic solution of iodine, which in that case will produce the characteristic blue colour indicative of the presence of starch.

13. Not only is coffee adulterated in the manner described, but the adulterating substance itself is often sophisticated. Thus ground chicory is often mixed with *torrefied ground rice* and *corn*, *roasted biscuit* or *bread*, which are cheaper than chicory. The presence of these substances may be detected in chicory as in coffee, by means of a solution of iodine, and also because, when thrown into an inverted bottle or funnel, as above described, the chicory absorbing water more rapidly, falls at the bottom first, and may be separated, as we said before.

14. Chicory powder has been adulterated also with *brick-dust*, *ochre*, and other earthy matters, the presence and amount

of which, however, may be most readily determined by incinerating a given weight of the suspected article ; 100 grains of pure chicory yield from 4 to 5 grains of fixed residue, the excess indicates the fraud.

15. On the Continent, the material chiefly used to adulterate both *chicory* and *coffee*, is coffee grounds ; this may be detected by first drying the suspected chicory in a water bath, and throwing a pinch of it, when dry, in water, as above directed ; the chicory absorbs the water and sinks to the bottom of the vessel, whilst the *coffee grounds* remain on the surface. When, however, coffee is adulterated with coffee grounds, I know of no other way of detecting it but by the strength of the infusion, which in that case, of course, is less in proportion to the extent of the fraud.

16. But, as we said at first, the best guarantee of the genuineness of coffee is in the berry, which cannot be adulterated, and which, if damaged, may be immediately recognized as being so, by smelling it and chewing a few grains. To the consumer, we would therefore say as a general rule, "never buy ground coffee, if you can help it."

17. Coffee is also met with in commerce as a manufactured article, in the state of essence, or rather of extract of coffee. That preparation, provided it be genuine, is peculiarly adapted to the use of travellers, who are thus enabled to procure a cup of very good coffee without trouble and apparatus. Of all the attempts which have been made to manufacture such an extract, and of most of which I have had samples, I have found on examination, that only one kind, that manufactured by Dunn, of Pentonville, would keep. All the other samples which have come under my notice were (some of them) very good indeed ; but the extract very soon fermented, in a few days it became aced, and shortly afterwards, altogether sour and undrinkable, notwithstanding its being kept in the dark, well corked, in a cool place, and, in fact, despite every precaution of a practicable kind which I adopted to prevent the change

alluded to, and which finally converted the article into a mucilagenous ropy, acid extract, of a very disagreeable odour and flavour.

18. Dunn's extract of coffee, on the contrary, remains good, even after months, possibly after years, provided the bottle containing it, and which is of black glass, is kept well corked. If this precaution is not observed, Dunn's extract will also, in the course of a fortnight, more or less, become first vapid, and then it will ferment and turn acid. But, as I said, if kept carefully corked in its bottle of black glass, it will undergo no perceptible change, at least in the course of six months, which is the longest period during which I kept one of the bottles of extract, after having occasionally removed part of its contents, and carefully replaced the cork.

19. I think I can confidently assert, that Dunn's essence of coffee is the only one which has stood ground ; all other attempts, for some reason or other, having hitherto proved failures, and eventually been abandoned.

20. The above essence is described on the label, as being made of the best Turkey coffee, and I have every reason to believe that the statement is correct. Another quality is made by the same process, with *plantation coffee* ; this I have not tried.

21. Since I wrote the above, I have tried another essence of coffee, manufactured by Smith, of Edinburgh, and it appeared to me very good, but I do not know whether it will keep.

COLOGNE YELLOW.—See *Chromate of Lead*.

COLOPHONIUM.—See *Rosin*.

COLOURED PAPERS.—See *Blanc Mange*.

COPAIBA.

BALSAM OF COPAIBA.

1. Copaiba is a liquid rosin, improperly called balsam of copaiba, which exudes principally from the *Copaïfera officinalis* and *Copaïfera bijuga*. Its composition is stated by Gerber and Stobze, as follows :—

Volatile oil	.	.	32.0	to	47.00
Copaivic acid	.	.	38.0	to	52.00
Viscid rosin	.	.	1.65	to	2.13

2. Balsam of copaiba is a liquid of an oily consistence, transparent, of a yellowish white colour, of a strong, disagreeable odour, and of a bitter, acrid, nauseous flavour. It thickens by exposure, and becomes more yellow ; its specific gravity is 0.95, and it is perfectly soluble in rectified alcohol. The balsam of copaiba which comes from Brazil is considered the best ; that from the West India Islands is less limpid than the other.

3. Formerly, balsam of copaiba was frequently adulterated with fixed oils ; but as it is entirely soluble in rectified alcohol, the fraud can at once be detected by treating the suspected balsam with that menstruum which will leave the oil undissolved. This adulteration, however, is seldom resorted to now, and instead of the ordinary fixed oils, castor oil, which is also soluble in alcohol, is more ordinarily employed for the purpose. This sophistication may be detected in various ways.

4. *Mr. Adder's process* consists in mixing the balsam with a solution of caustic soda, and agitating the whole violently. The liquor becomes milky at first, but if it be left at rest for a few hours, the balsam, if pure, gradually separates without alteration, and finally floats upon the

alkaline solution which has become transparent ; but if the balsam contains castor oil, a homogeneous soapy mass is formed of a thick, or even solid nature.

5. *Mr. Henry's process* consists in boiling the suspected balsam, for example, one drachm, in about a pint of water, in an open vessel. After boiling it for four or five hours, the balsam, if pure, will have been converted into a dry, brittle rosin, with a vitreous fracture ; but if it contains castor oil, it will be left in the state of a more or less plastic mass proportionate to the quantity of castor oil with which it may have been mixed.

6. A simpler method of obtaining the same result consists in pouring a drop of the balsam upon paper, and carefully evaporating it over a lamp. If a transparent and hard spot is left on the paper, the balsam is pure ; in the contrary case the film of rosin left on the paper will be soft, and an oily stain will be observed all around it, which is due to the absorption of the oil by the paper.

7. *Another process* consists in putting into a watch glass three drops of the balsam under examination, and then adding one drop of concentrated sulphuric acid by the side of it. At the point of contact the mass becomes yellowish, and becomes of a saffron colour all through, on stirring it with a glass-tube. But if the balsam contains any castor oil, it turns yellow at first, and soon becomes decolorized, and has the appearance of white honey. In either case the mass is ultimately charred by a prolonged contact.

8. *Mr. Planche's process* consists in mixing three parts (by measure) of the balsam with one part of dilute ammonia of sp. gr. 0.965, or weaker still, the mixture should be made in a glass tube closed at one end and well corked. The whole is then shaken, and if the copaiba be pure, the mixture becomes transparent in the course of a few minutes ; but if it contain any castor oil, it forms a liniment the opacity of which is in proportion to the quantity of castor oil present. To ensure success the temperature should not

be above 70° Fahr. The presence of one twentieth part of castor oil may be detected by this process.

9. *M. Blondeau's process* consists in triturating one part of the balsam with four parts of carbonate of magnesia well pulverized, the mixture is then left at rest, and in the course of a few hours it becomes transparent, but thick, like a mucilage of gum arabic; but if castor oil is present the mixture remains turbid. The magnesia may be dissolved with effervescence by an acid, and the balsam will then remain transparent, if pure, but in the contrary case, it is opaque.

10. Balsam of copaiba has been sometimes adulterated with Venice turpentine; when this is the case the balsam is thicker than when genuine, and when heated upon a hot iron the odour of turpentine is immediately rendered perceptible. When balsam of copaiba contains turpentine it adheres to the sides of the bottle in which it is contained, which is not the case with the pure article.

COPAL.

1. Copal is a resin which exudes spontaneously from several large trees in America, East India, and on the coast of Guinea. The best copal is generally in lumps of moderate size, colourless, or slightly yellowish, rather dull externally, but clear internally; sometimes also it is yellow or brownish and mixed with insects and other detritus.

2. The specific gravity of copal varies from 1.045 to 1.139. It is hard, inodorous, tasteless, and has a conchoidal fracture.

3. Gum anime is often sold under the name of copal, or copal is often mixed with lumps of gum anime, or of gum dammar, both of which it somewhat resembles. The two latter resins, however, may be distinguished from copal by careful observation. Both resin anime and dammar soften in the mouth, but genuine copal remains perfectly hard.

4. The best way of detecting the admixture of resin dammar, or of resin anime, with copal, consists in treating a given weight of the resin under examination, with highly rectified alcohol, which dissolves both the dammar and the anime, but leaves the copal in the state of a viscid, swollen, and somewhat elastic mass.

5. Copal has sometimes been mixed with pieces of insoluble gum. When the lumps are sufficiently large, the fraud can hardly fail being immediately detected, the external appearance of the pieces of gum being most obviously different. But when the whole is broken in small fragments, the admixture cannot be so easily detected by its physical characters. Resin copal, however, being completely soluble in ether, whilst gum is altogether insoluble in that menstruum, the two substances may thus be most readily separated.

COPPER.

ANALYSIS OF COPPER ORES.

1. The principal copper ores are the oxyde, chloride, sulphuret, sulphate, phosphate, carbonate, and arseniate of copper.

2. If the object in view be merely to ascertain the quantity of copper present in the ore, proceed as follows:—Take 50 grains of the ore and dissolve them in hydrochloric acid, in nitric acid, or in aqua regia; filter, in order to separate the insoluble portions, and evaporate the filtrate in order to expel the excess of acid. To the concentrated liquor add an excess of the strongest solution of ammonia, which will dissolve the oxyde of copper, and precipitate the iron, which may be separated by filtering, and washed. The ammoniacal filtrate should then be boiled with an excess of caustic potash until all the copper is precipitated as oxyde of copper, in the form of a heavy brownish black precipitate,

which is separated by filtering, washed with hot water until all the potash is eliminated, dried, and then ignited in a covered platinum crucible, and weighed immediately after cooling. 40 of oxyde of copper = 32 of metallic copper.

3. It is advisable to redissolve the precipitate in hydrochloric acid and to repeat the process above described. The second weighing should of course correspond with the first.

4. *Another method* of analyzing copper ores by which the quantity of copper in ores may be rapidly estimated with great accuracy is that contrived by M. Pelouze, namely, by precipitating the ammoniacal solution by a test-solution of sulphuret of sodium; the operation is known to be at an end as soon as the blue colour of the liquor disappears. The *modus operandi* is as follows:—

5. The operator should first prepare the test-liquor of sulphuret of sodium, by dissolving 1000 grains of sulphuret of sodium in one pint of distilled water. On the other hand, he should dissolve 20 grains of very pure copper in nitric acid, and the solution being slightly diluted with water a large excess of ammonia must be added, which produces an intensely blue solution. This blue ammoniacal solution is then heated to ebullition, and a portion of the test-solution of sulphuret of sodium is now poured from an alkalimeter into it, the operation being conducted as in alkalimetry. (See *Alkalimetry*). Let us suppose, for example, that 40 divisions of the solution of sulphuret of sodium in the alkalimeter have been required to decolorize that of the 20 grains of copper, the operator at once knows the strength of the test-liquor, that is to say, 100 divisions (1000 grains-measure) of such a solution will represent 50 grains of copper, or be capable of decolorizing a solution containing that quantity.

Divisions.	Gr. of Copper.	Divisions.	Gr. of Copper.
40	: 20	: : 100	: 50

6. Having thus prepared the test-liquor, and ascertained its strength, the operator should now take a known weight

of the copper ore, previously well pulverized; for example, 25 grains, and dissolve them in an excess of aqua regia. The action of the acid having ceased, the excess of acid is evaporated, and the flask is allowed to cool, after which a large excess of ammonia is poured in.

7. The substances which were undissolved by the acid, and those which the ammonia may have precipitated; such as *silica*, *alumina*, *oxyde of lead*, *oxyde of antimony*, *peroxyde of iron*, need not be separated by filtering, for they do not interfere with the decolorization, nor have they any action on the sulphuret of sodium, except after all the copper has been precipitated. But if the ore contains any *tin*, this metal remains in suspension in the ammoniacal solution, and takes a very long time to settle. The liquor, in that case, should be filtered, though it has been observed that the addition of a small quantity of nitrate of lead hastens the precipitation of the stannic acid. When, however, the liquor is turbid, so as to prevent discerning the exact decolorizing point, it should be filtered.

8. The blue ammoniacal solution should now be heated to ebullition, and a portion of the test-liquor of sulphuret of sodium is then poured from an alkalimeter tube until the decolorizing point is hit, taking care to add dilute ammonia from time to time, in order to replace that which evaporates. The weakening of the blue colour indicates that the experiment is drawing to a close, and towards the end the sulphuret of sodium should be added, drop by drop, exactly as in alkalimetry.

9. Suppose, for example, that it be found that 22 divisions of the alkalimeter have been required; then, since 100 divisions of the sulphuret of sodium test-liquor represent 50 grs. of copper (see page 212 § 5), 22 divisions evidently indicate 11 grains of copper.

$$100 : 50 :: 22 : x = 11.$$

10. The 25 grains of copper ore experimented upon contained, therefore, 11 of metallic copper, or 44 per cent.

11. The above process is applicable, not only to the ores of copper, but likewise to the estimation of this metal in most of its alloys, the presence of *lead, tin, zinc, cadmium, iron, antimony*, do not interfere, because they re-act on the alkaline sulphuret only after all the copper has been precipitated; but *silver, mercury, cobalt, and nickel*, must not be present. The silver, however, might be eliminated beforehand by means of muriatic acid. The ammoniacal liquor, from which the copper has been precipitated by the alkaline sulphuret, remains colourless only for a short time, and gradually becomes blue again, because the sulphuret of copper precipitated absorbs oxygen, and is thus transformed into sulphate of copper. This, however, may be avoided by removing with a jet of ammoniacal water the small portions of precipitate which adhere to the sides of the glass above the level of the liquor; the sulphuret settles then completely at the bottom of the vessel, and being thus sheltered from the action of the air by the supernatant liquid, cannot produce any blue reaction.

12. The errors by this process do not exceed four or five thousandths; and even this trifling amount may be reduced by employing a very weak solution of sulphuret of sodium towards the end.

13. When copper has to be estimated in a salt which contains a protosalt of iron, as is frequently the case with the *sulphate of copper of commerce*, the operator must not omit to peroxydize the iron by means of nitric acid, otherwise the protoxyde of iron precipitated by the ammonia would take up a portion of oxygen from the oxyde of copper which would then be precipitated in the state of basic sulphuret of copper (Cu_2S), which would render, of course, the analysis inaccurate.

ANTIMONIATED GREY COPPER.

14. Seven varieties of this ore from various localities have been carefully analyzed by H. Rose, the result of five of these analyses are given below ; the first is due to Klaproth.

KLAPROTH.

H. ROSE.

Constituents.	Clausthal.	Dillenburg.	Alasee.	Freyburg.	Fursten- berg.	Clausthal.
Copper ...	37.50	38.42	40.60	14.81	25.03	34.48
Arsenic ...	0.00	2.26	10.19	0.00	0.00	0.00
Antimony	29.00	25.27	12.46	24.63	26.63	28.24
Iron	6.50	1.52	4.66	5.98	3.72	2.27
Sulphur...	21.50	25.03	26.83	21.17	23.52	24.73
Silver ...	3.00	0.83	0.60	31.29	17.71	4.97
Zinc	0.00	6.85	3.69	0.99	3.10	5.55
Silica	0.00	0.00	0.41	0.00	0.00	0.00
	97.50	100.13	99.44	98.87	99.91	100.24

15. The analysis of the above ore may be performed as follows :—

16. The ore should be first reduced into very fine powder, and then a portion should be treated by aqua regia, and boiled until the sulphur separated appears with its characteristic yellow colour, and is agglomerated into lumps ; the solution should then be diluted and filtered, and ammonia added to the filtered liquor, nearly to saturation. A solution of nitrate of baryta must now be poured into it, which produces a white precipitate of sulphate and of arseniate of baryta, in which the presence of arsenic may be immediately detected by mixing a portion of the precipitate with carbonate of soda, and heating it before the blow-pipe upon charcoal. The precipitate is then treated by nitric acid, and that which remains in an insoluble state is sulphate of baryta, which may be separated by filtering, then washed, dried, ignited, and weighed. From the collective weight of the sulphate of baryta, and of the yellow lumps of sulphur obtained before,

the whole quantity of the sulphur contained in the ore becomes known.

17. An excess of ammonia is now to be poured into the liquor filtered from the precipitated sulphate and arseniate of baryta ; this produces at first a precipitate of oxyde of zinc, of copper, and of peroxyde of iron ; but the excess of ammonia re-dissolves both the oxydes of zinc and copper, whilst the peroxyde of iron remains in an insoluble state ; the ammoniacal filtrate in that case is of course blue, since it contains the copper. As, however, the peroxyde of iron precipitated retains a somewhat considerable portion of zinc (if that metal be present), it is advisable to re-dissolve it in hydrochloric acid, and to reprecipitate it by neutral succinate of ammonia, as follows :—The acid solution is to be nearly neutralized with ammonia, until a few flakes of peroxyde of iron begin to appear, and the precipitation of the iron is then completed with solution of neutral succinate of ammonia ; the precipitated persuccinate of iron may now be washed, dried, ignited, and weighed, as peroxyde of iron free from oxyde of zinc.

18. The liquor filtered from the persuccinate of iron might now be mixed with the solution of caustic potash, and boiled, in order to precipitate the oxyde of copper, since oxyde of zinc is soluble in excess of potash ; but this method does not yield accurate results, because the oxyde of copper thus precipitated retains a large proportion of oxyde of zinc, however considerable the excess of potash employed may be.

19. It is necessary therefore to redissolve the hydrochloric acid, the oxyde of copper thus precipitated, and to pass a current of sulphuretted hydrogen through the acid solution, by which means the copper is precipitated in the state of sulphuret of copper (black), which must be immediately collected on a filter, and washed, without interruption, with water, containing a little sulphuretted hydrogen. The sulphuret of copper so obtained may now be dried, in order that it may be easily removed from the filter, and put into a

glass-beaker ; the filter is to be burnt on the cover of a platinum crucible, and the ashes are put into the beaker along with the sulphuret, after which, aqua regia is poured in, and the whole is left to digest, until the sulphur which separates has acquired its characteristic yellow colour. The sulphur is then separated by filtering, and caustic potash being poured in the filtrate, a voluminous blue precipitate of hydrate of protoxyde of copper is produced, which becomes black by boiling. This heavy, black, or brownish-black precipitate is collected on a filter, washed with hot water, in order to eliminate the potash completely, it is then dried and ignited with the filter. As soon as the ignition is completed the crucible should be closed with a well-fitting cover, and weighed as soon as cold. 40 of protoxyde of copper represent 32 of metallic copper.

20. The liquor filtered from the precipitate produced in the first instance by potash and which contains the zinc in solution, must now be mixed with that which was filtered from the sulphuret of copper, ammonia and then sulphuret of ammonia being now added, a white precipitate is produced, which is sulphuret of zinc, and which must be treated exactly as we described in the article on the analysis of *Zinc Ores*, which see.

21. *Antimony* may be separated from the other metals in the ore by dissolving another portion of the ore, as described at the beginning of this article, supersaturating the filtrate with ammonia, and pouring into it a large excess of hydrosulphuret of ammonia in maximum of sulphur, corking the flask, and leaving it for several hours in a warm place ; all the metals in the compound are thereby precipitated, in the state of sulphurets ; but sulphuret of antimony, being soluble in excess of hydrosulphuret of ammonia, is taken up by that re-agent ; the flask, after several hours, is allowed to cool, and then filtered ; the sulphurets, except that of antimony, remains on the filter, and should be washed with water, containing a little hydrosulphuret of ammonia. The

filtrate contains now in solution the whole of the sulphuret of antimony, which should be precipitated by supersaturating the liquor with the dilute hydrochloric acid, and the whole should be left at rest in a warm place, until it no longer exhales the odour of sulphuretted hydrogen; the sulphuret of antimony is then collected on a counterpoised filter, dried, and treated as described in the article on the ores of antimony to which the reader is referred.

22. Antimony is known to be present in the compound, when, on diluting the original solution with water, a white precipitate is produced, which, being collected and dissolved in hydrochloric acid, and then treated by sulphuretted hydrogen, produces an orange-red precipitate.

23. In order to ascertain whether silver is present, take a known weight of a fresh portion of the ore, dissolve it in nitric acid, dilute the solution with water, filter, and then test the filtrate with hydrochloric acid. If silver is present, a white precipitate will be produced, soluble in caustic ammonia. The precipitated chloride of silver thus produced may be collected on a filter, washed, dried, fused in a small porcelain crucible, and weighed. 134 grains of chloride of silver represent 108 grains of silver; or 1 grain of chloride of silver contains 0.75330 of silver.

WHITE COPPER.

24. This ore contains *copper, arsenic, iron, sulphur*, and *silica*; its analysis may be made in the same manner as that of grey copper, but it is less complicated; it is as follows:—The ore is first reduced to very fine powder, and then treated by aqua regia until the sulphur which separates has agglomerated into yellow lumps. The solution is then filtered in order to separate the silica and the sulphur, which should be well washed, and, on igniting it, the sulphur volatilizes and leaves the silica alone. The solution which was filtered from the sulphur and silica is then treated by an excess of nitrate of baryta, which produces a white precipitate of sulphate of

baryta, from the weight of which, conjointly with that of the yellow lumps of sulphur above alluded to, the whole quantity of the sulphur in the compound becomes known. If ammonia be now added to neutralization, a precipitate of arseniate of baryta and of iron is produced, in which precipitate the presence of arsenic may be readily detected by mixing it with soda, and heating it before the blow-pipe upon charcoal, when the characteristic odour of garlic will become perceptible. The liquor filtered from the precipitate contains the copper, and is blue; it may be precipitated as usual by a solution of potash.

25. The presence of arsenic in the ore, however, may be ascertained at the beginning by heating a portion of it mixed with soda before the blow-pipe upon charcoal.

COPPER PYRITES.

26. The analysis of copper pyrites is performed exactly as that of the ore last mentioned; according to Thomson, its constituents are as follow :—

	Anglesea.	Cornwall.
Sulphur . . .	33.01	34.65
Copper . . .	32.95	33.04
Iron . . .	33.04	31.53
Earthy matter	0.00	0.55
	100.00	100.00

SULPHURET OF COPPER.

27. (*Vitreous copper*) is a combination of sulphur and copper, with an admixture of iron and of silica in the following proportions :—

	Siberia.	Cornwall.	Siegeuseben.	Nova Scotia.
Copper	78.50	77.16	79.50	79.5
Sulphur	18.50	20.62	19.00	18.0
Iron	2.25	1.45	0.75	2.5
Silica	0.75	0.00	1.00	0.0
	100.00	100.00	100.00	100.0
	Klaproth.	Thomson.	Ullman.	Jackson.

28. Sulphuret of copper may be analyzed by boiling a weighed portion of the sample, previously pulverized, in aqua regia, until the sulphur has separated in lumps of a perfectly yellow colour, the solution is then diluted with water and filtered, in order to separate the silica and the agglomerated sulphur, which may be estimated as described in the analysis of *copper pyrites*. The filtrate is usually treated by an excess of ammonia, which precipitates the peroxyde of iron, which is collected on a filter, whilst the liquor filtered therefrom, and which is of a fine blue colour, holds the copper in solution. This method, however, is inaccurate, because the precipitated peroxyde of iron retains a considerable proportion of copper, which cannot be taken up completely by any excess of ammonia. It is, therefore, much better to pass a stream of sulphuretted hydrogen in the solution of the mineral, the copper falls down as sulphuret of copper, which is black. The stream of gas should be passed slowly through the solution, and continued until the liquor smells strongly of it; the sulphuret of copper so produced should be rapidly collected on a filter, washed with water containing a little sulphuretted hydrogen, and treated in every way as was said before.

29. The filtrate from the sulphuret of copper should next be heated until all odour of sulphuretted hydrogen has vanished, and an excess of ammonia being then poured into it, the peroxyde of iron is thereby precipitated, collected on a filter, dried, ignited, and weighed.

30. The ore may also be roasted, as well as possible, in the manner described below when speaking of the analysis in the dry way, and boiled with concentrated hydrochloric acid. The solution of the ore is then treated exactly as above described, or, after having nearly evaporated the excess of acid, the solution should be diluted with water, filtered, and the copper may then be precipitated by a bar of zinc or of iron. The copper thus precipitated is washed with water, carefully dried, and weighed.

Analysis in the dry way.

31. The analysis of sulphuret of copper in the dry way may be performed in various ways. One of my friends, Dr. Ehrenberg, communicated to me the following process which I have somewhat modified, and which I can recommend as giving accurate results. Take a weighed quantity of the ore and roast it completely, so that all the sulphur and sulphuric acid may be eliminated. This is best accomplished, by putting the above weighed quantity of the sulphuret in a crucible, and when the mass is roasted as much as possible, one tenth of its weight of carbonate of ammonia is gradually added, whilst the mass is kept at a red heat, the whole being diligently stirred and thoroughly mixed. When all the carbonate of ammonia has been well incorporated with the mass, as just said, the temperature is brought to a bright red heat for a few minutes, by which means the last traces of sulphur evaporate with the ammoniacal vapour. If the ore contains much arsenic, which is frequently the case, some charcoal should be added during the roasting, previous to the addition of the carbonate of ammonia. Take now about 400 grains of the roasted mass, and about 600 grains of carbonate of soda, put the whole in a mortar, and triturate it carefully. Put the mixture into a *brasque crucible*,* and strew over the whole about 400 grains of borax. The crucible is now put in the fire and kept at a dark red heat for about a quarter of an hour, after which the temperature should be increased to a bright red heat, which is to be maintained for about twenty minutes, or in fact until the borax has fused into a perfectly smooth surface. The crucible is then allowed to cool, and

* A brasque crucible may be most conveniently made by filling a common Hessian crucible with lamp black, by small portions at a time, and strongly pressing each portion with a ramrod, or small pestle. The crucible being thus filled up with the compressed lamp black, a hole of a suitable dimension may be scooped out with a knife, and the sides of the hole are then polished with a glass-rod. A brasque is, therefore, a charcoal or lamp black crucible within an ordinary crucible.

when cold, a button of metallic copper will be found at the bottom of the crucible. It is important that the ore should be perfectly roasted before hand, for if it retains any sulphur, the slag invariably contains some copper.

CARBONATE OF COPPER.

32. (*Blue carbonate of copper. Azurite.*) This ore is a combination of oxyde of copper, carbonic acid, and water. Mr. R. Phillips gives the following results of an analysis of this ore.

	Chessy.
Oxyde of copper	69.08
Carbonic acid	25.46
Water	5.46
	100.00

33. The quantity of copper is easily determined; a weighed portion of the ore is first reduced into fine powder, and then treated in a flask by hydrochloric acid, which produces an effervescence due to a disengagement of carbonic acid. The oxyde of copper is then precipitated in the usual way by potash; or the copper may be precipitated from the solution by means of a clean blade of iron, or of zinc.

COPPERAS (BLUE).—See *Sulphate of Copper*.

COPPERAS (WHITE).—See *Sulphate of Zinc*.

COPPER PYRITES.—See *Copper Ores*.

CORROSIVE SUBLIMATE.

PROTOCHLORIDE OF MERCURY. BICHLORIDE OF MERCURY. OXYMURIATE OF MERCURY.

1. Protochloride of mercury (Hg Cl), or corrosive sublimate, is a compound of mercury and of chlorine, until lately *

known as bichloride of mercury. It has a nauseous, disagreeable, and persisting metallic taste. It is generally met with in commerce in white, acicular, imperfectly crystallized masses, semitransparent on the edges, convex, even, and shining on one side, concave, and full of small confused crystals on the other side; sometimes also in small detached crystals which slightly effloresce by exposure; it is a most virulent poison. The specific gravity of corrosive sublimate is 5.398.

2. Corrosive sublimate is generally pure. Exposed to a red heat, it should liquify and then volatilize entirely. At a less degree of temperature it volatilizes also without undergoing fusion. It should dissolve completely in sulphuric ether, and likewise in three parts of cold alcohol. It is totally soluble in water, and sulphuric ether takes it up from its aqueous solution. If it contains any subchloride of mercury (calomel), a residuum is left when dissolved in water, calomel being insoluble in that menstruum.

3. The aqueous solution of corrosive sublimate is decomposed and precipitated by lime-water, or by solution of potash in the form of a yellow precipitate, which precipitate should also be completely volatilizable by heat. Any residuum is an impurity, the amount of which may be directly ascertained by weighing.

COTTON AND LINEN.

1. Linen fabrics are often mixed with cotton. M. Kindt proposed, as a means of detecting these two substances from each other, a method which is grounded upon the power which concentrated sulphuric acid possesses of dissolving the cellulose of cotton more rapidly than that of flax.

2. The mode of proceeding is as follows:—A portion of the tissue is first boiled in water, in order to remove the stiffening, it is then dried, cut in half, weighed, and one of

the halves is plunged into concentrated sulphuric acid for two minutes. The tissue which has then become transparent is again boiled in water, for the purpose of removing the gummy substance produced ; this removal may be promoted, if needful, by friction between the fingers. The acid is ultimately eliminated by washing the tissue with a weak solution of alkali, then with pure water, after which it is dried. As in this process the threads of cotton have been dissolved, their amount may be immediately determined by the loss as compared with the portion which has not been submitted to the action of the sulphuric acid.

3. If the piece were left too long in the acid the flax would likewise be attacked, but if the tissue contain no cotton, the corrosion will have been uniform, whilst in the contrary case, the cotton is first attacked and converted into gum, whilst the flax remains white and opaque.

4. A concentrated solution of caustic potash may also be employed for the purpose, as follows :—A piece of the tissue is to be boiled for two minutes in a strong solution of caustic potash, and then dried between folds of blotting paper. Upon unravelling it the linen threads will be found to have acquired a dark yellow tinge, whilst those of cotton have remained white, or have only become slightly tinged with yellow.

5. The presence of cotton in a tissue may also be detected by the microscope, the fibres of cotton having a flat and shrivelled appearance, whilst those of flax are round and straight.

6. *Cotton and wool.* To distinguish cotton from wool, boil a square inch of the tissue in a solution of caustic soda. The whole of the wool will be dissolved, whilst the cotton fibres are scarcely injured at all by this treatment ; and if the threads have been previously counted, their relative proportion may be thus directly estimated.

7. *Cotton from wool and silk.* If the tissue be white, the presence of silk or of wool may be distinguished from cotton

by means of chlorine, for if the tissue be exposed to the action of this gas the wool or the silk becomes yellow, whilst the cotton remains white.

8. The presence of cotton may be most easily recognized and distinguished from wool and from silk by unravelling the suspected tissue, and inflaming the threads so unravelled. Wool and silk threads, when so treated, shrivel up, burn with difficulty, and with a characteristic odour, and leave a voluminous charcoal whilst cotton threads burn rapidly, leave no charcoal, and evolve no odour.

CREAM OF TARTAR.—See *Bitartrate of Potash*.

CREASOTE.

“Creasote is a product of the dry distillation of organic bodies, and the peculiar preservative principle of smoke and pyroligneous acid. It prevents the decomposition of meat, and thence its name from *κρεας* (flesh) and *σωζειν* (to preserve).

“It is chiefly manufactured from wood-tar, in which it is sometimes contained to the amount of 20 per cent. Its components are carbon, hydrogen, and oxygen, in a proportion not yet precisely ascertained.

“It is a colourless and transparent liquor, specific weight of little more than water, of a peculiar, unpleasant, penetrating odour, and of a very pungent and caustic taste; it acts in a state of concentration like a poison, makes the eyes feel painful, boils at 203° centig. = 397° Fahr., does not consolidate even at 21° centig. = — 5° 8 Fahr.; produces on paper greasy spots, which afterwards disappear; dissolves in 80 parts of water, and mixes in any proportion with spirit of wine, ether, essential and fat oils, acetic acid, and ammonia. It dissolves

iodine, phosphorus, sulphur, resins, and alkaloids. The aqueous solution is perfectly neutral, and precipitates solutions of gum and the white of eggs. Sp. gr. 1.037 at 68° Fahr.

“Creasote is easily distinguished by its odour. If of a good quality, it possesses the following properties :—

“*a.* If shaken with an equal volume of water in a narrow test-tube, not more than the eightieth part disappears; otherwise it contains water, of which creasote is able to absorb $\frac{1}{10}$ th, without becoming turbid.

“*b.* If it can be dissolved completely in 80 parts by weight of water at a medium temperature, it then forms a perfectly neutral liquid. An oily residue floating on the surface betrays the presence of other foreign products, as eupione, capnomore, picamar, which are obtained at the same time with the creasote during the dry distillation of organic substances.”—(*Annals of Chemistry.*)

Pure creasote is colourless, but that met with in commerce has generally a straw, or even, when very impure, a brown colour. According to Dr. Pereira these impurities may be detected by mixing separate portions of the suspected liquid with acetic acid and caustic potash, pure creasote being completely soluble in these fluids, whilst the impurities not being so may thus be isolated.

CRUDE ANTIMONY.—See *Sulphuret of Antimony.*

CRUDE TARTAR.—See *Bitartrate of Potash.*

CRYSOCOLLA.—See *Borax.*

CRYSTAL.—See *Glass.*

CUBIC NITRE.—See *Nitre (Cubic)*.

CUTCH.—See *Catechu*.

DUTCH GOLD.—See *Brass*.

DUTCH WHITE.—See *Carbonate of Lead*.

ELECTRUM.—See *German Silver*.

EPSOM SALTS.—See *Sulphate of Magnesia*.

ESSENTIAL OILS.—See *Oils*.

ETHER.

SULPHURIC ETHER.

1. Ether is the name of a compound which is produced in a great number of circumstances, but which is principally formed when alcohol is made to re-act upon sulphuric, muriatic, nitrous, acetic, arsenic, phosphoric acids, fluoride of boron, &c. concentrated sulphuric acid, however, transforms alcohol into ether more easily than any other substance; and that ether is almost exclusively used both for manufacturing purposes and in the laboratory.

2. Pure sulphuric ether is colourless, and very fluid; it has a peculiar strong penetrating but agreeable odour, and a burning, pungent, sweetish flavour. It should be perfectly neutral to test papers.

3. The ether of commerce is generally unsophisticated, but it is nevertheless found much less pure or strong than should be. The only adulteration to which sulphuric ether is liable, is by an admixture of alcohol, in which it is soluble in all proportion. The presence of alcohol in ether, however, is very easily recognized by pouring a certain quantity of the suspected ether into a graduated tube, and adding a small quantity of water, which, dissolving the alcohol, produces a much more considerable diminution of volume, if the ether contain that body, than when it is pure; of course the mixture should be shaken. It should be recollected that 10 parts of water dissolve 1 of ether; and, consequently, that a diminution in that proportion will always take place, even with pure ether, for which an allowance must be made.

4. The alcohol employed in the manufacture of ether should be very pure, or well rectified, otherwise the ether will have a much less agreeable or even an unpleasant odour, due to the presence of *fusel* or other essential oil.

5. The specific gravity of good ether is 0.775.

6. The oxygen of the air slowly acidifies sulphuric ether, owing to which it frequently reddens litmus paper; such ether should be redistilled with potash or caustic magnesia. The operator in doing this should bear in mind that the vapour of ether is highly inflammable and *heavy*, and that it frequently happens that in falling upon *red hot* coals, or the flame of gas, of candles, or of other ignited bodies, it may catch fire, and cause serious accidents.

7. Ether is principally used as a solvent in certain analytical operations, to detect and isolate bromine, and in the preparation of a great number of organic bases, &c.

8. Sulphuric ether is sometimes used as an anæsthenic agent, but chloroform is now generally employed in preference.

FERROCYANIDE OF POTASSIUM.

YELLOW PRUSSATE OF POTASH.

1. The ferrocyanide of potassium of commerce is generally in large and beautiful crystals of a fine lemon yellow colour, which should be entirely soluble in alcohol.

2. The yellow prussiate of commerce is sometimes contaminated by sulphate of potash, the presence of which may be detected by dissolving a portion of the salt in water, and adding thereto a solution of chloride of barium, or of nitrate of baryta, which will then produce a white precipitate of sulphate of baryta, insoluble in water and in acids, if sulphate of potash be present. The precipitated sulphate of baryta should be collected on a filter, washed, dried, ignited, and weighed; 117 grains of sulphate of baryta correspond to 88 grains of sulphate of potash.

3. This substance has become an important article of commerce, large quantities of it being consumed by calico printers and dyers, by the manufacturers of Prussian blue, and in electro plating.

FIXED OILS—See *Oils*.

FLOUR.

1. M. Dumas in his 'Traite de Chimie,' says :—

“The most direct manner of appreciating the quality or yield of flour would be to make bread with it in the ordinary way, by taking very equal quantities of flour and of water, and kneading them at the same temperature and for the same length of time, in a small kneading machine (*pétrin mécanique*), raising the dough by means of equal quantities of

solution of bicarbonate of soda, decomposed at the very moment of putting it in the oven by a given quantity of alum rapidly mixed with the dough ; and lastly, baking the latter in a small oven kept at a uniform temperature by means of an oil-bath."

2. Such a method, however, appears to me exceedingly troublesome and uncertain, neither does it fulfil the desideratum, for the object is not merely to ascertain the *yield* of the flour, but indeed the *quality* of the bread produced.

3. If the yield were always in proportion to the quality, the method above alluded to might perhaps become available, to a certain extent, but we have seen, in the article on *Bread* that such is not the case ; or, at least, that with flour of an inferior quality, the baker generally contrives to obtain a quantity of bread *equal in weight* to that which better descriptions of flour would give. It is therefore better and safer to test the quality of the flour by ascertaining the amount of foreign matter which may have been mixed with it.

4. The substances principally employed for the purpose of adulterating wheat flour, are *fecula* or *potato starch*, *bean flour*, *Indian corn flour*, *rye*, and *rice flour*, which alimentary substances are objectionable only when the flour containing them, or the bread made with such flour, is sold as genuine wheat flour or bread ; but besides these, so far venial additions, flour is sometimes sophisticated by *alum*, *chalk*, *bone-dust*, and *plaster*, and it is more especially against these that the rigour of the law should be enforced.

Detection of Fecula, or Potato Flour.

5. The admixture of potato flour or fecula to wheat flour, may very well be detected by the microscope. The particles of potato starch are irregular in shape, and of various sizes, and moreover, upon placing a little of the suspected flour

before the microscope, and moistening it with a solution of potash, the particles of wheat flour undergo no change whatever, whilst the globules of fecula spread into thin, transparent plates.

6. Although the presence of fecula can be detected even when in extremely minute proportion, yet it would appear that its quantity cannot be very rigorously estimated when under 10 per cent. ; but an adulteration below 10 per cent. is scarcely probable, since it would hardly, if at all, be remunerative ; on the other hand, Dumas asserts, that when fecula is added to wheat flour, to the extent of 30 per cent., it is impossible to make bread with it. It may therefore be assumed that the addition of fecula to wheat flour ranges from 10 to 25 per cent., but, as we said before, the presence of a much more minute quantity can be detected.

7. One of the methods of doing this is the following, which according to M. Chevallier can be applied with advantage, not only to flour which has been simply mixed with fecula, or which has been ground with it, but likewise to vermicelli, macaroni, &c.

Take of the flour under examination	300 grains.
Sand	300 ditto.
Water	2 ounces.

Triturate the flour and the sand in a wedgewood mortar for about five minutes, adding the water gradually, so as to form a homogeneous paste, which is then to be diluted with the remainder of the water. This being done, throw the whole on a filter, and whilst filtering, prepare an aqueous solution of iodine, by pouring about two ounces of water upon about fifty grains of iodine, and shake the whole for about ten minutes ; the aqueous solution is then decanted, and the undissolved iodine is kept for further use. Of the aqueous solution of iodine so prepared, pour one ounce into an equal quantity of the liquor filtered from the flour. If

the flour was pure, this addition will produce a pink colour, which, however, gradually disappears more or less rapidly; whilst, if the flour contain ten per cent. of fecula, the liquor will become of a dark purple colour, which disappears much more slowly. This experiment had better be performed simultaneously with flour which is known to be pure.

8. If now, the liquor be examined after a short time, it will be seen that the colour of the liquor obtained from the pure flour begins to disappear from the bottom of the glass upwards, and in the course of eight or ten minutes, it completely disappears, whilst, if fecula be present, the decolourization begins likewise from the bottom upwards, but the purple or violet colour persists for a long time at the surface, so that the liquor forms two distinct strata, the lower of which is colourless, the upper one is purple.

9. *Another process* by which the quantity of fecula added to flour may be accurately estimated, is that proposed by M. Robine, it is as follows:—

Take 500 grains of the suspected flour, and mix it in a glass-beaker with a glass rod, with 200 grains of cold water. The whole being mixed to a doughy consistence, the mass is then squeezed in the palm of the hand, whilst holding it in a bason half full of water, by which means the gluten is separated, and ultimately left in the hand, in a pure state, under the form of an elastic and glutinous mass, which may be weighed. The small pieces of gluten which may have escaped, and have fallen in the bason, should be, of course, collected and weighed with the portions of gluten already obtained.

10. The water in the bason which contains the starch should now be well stirred, and poured, whilst turbid, into a conical glass (a six ounce glass-measure answers the purpose well), and the whole is then left at rest. At the end of an hour, a deposit will have formed at the bottom of the glass, which must be left undisturbed. When the whole has been left at rest for two hours, the supernatant liquor is care-

fully syphoned out, and the whole being left again undisturbed for two hours, any water which may be observed floating above the deposit, may be carefully sucked up by means of a pipette.

11. On examining the deposit, it will be found to be in two distinct layers ; the upper one has a grey colour, and consists of a mixture of gluten, in a finely divided state, and of albumen ; the lower layer, which is opaque and white, is starch.

12. The upper layer should be carefully removed with a teaspoon, down to the compact layer of starch, which is known, because it feels harder and stiffer ; the second layer should be left undisturbed, until it has become quite solid by drying. When it is in that state, it may be easily removed from the glass, by pressing it gently with the finger, all round, until it is detached, and it may then be upset in the form of a cone, upon a lump of dry plaster. The potato starch being heavier than that of wheat, forms the apex of the cone ; its thickness, or depth, and consequently its quantity, may be estimated by solution of iodine, in the following manner :—The operator cuts from the apex of the little cone above mentioned, a slice, which he triturates only for a short time in an agate mortar (one of glass, or porcelain, or wedgewood, will not do), and he tests that with solution of iodine. If it turn blue, it is fecula. Another slice is treated in the same manner, until the operator comes to the wheat starch, which, in the present instance, will not be affected by the aqueous solution of iodine. This difference of behaviour of the two species of starch with iodine, is due to the friction of the pestle and mortar, which is sufficient to divide or tear the envelopes of the particles of the potato starch, which then become blue, when treated by solution of iodine. The particles of wheat starch, on the contrary, are not disaggregated by that treatment, and being therefore protected by their envelope, are not acted upon by solution of iodine, or assume only a brown tinge.

13. Hot water, or heat in any way, must not be employed in that experiment, for it would burst the envelope containing the starch of the wheat, which would in that case be coloured blue also by solution of iodine, and, therefore, spoil the experiment. For the same reason, the cone of starch must be left to dry spontaneously, and not by applying heat; neither should trituration be continued too long. The asperities of a wedgewood mortar would tear the globules of starch, and produce the same effect as heat; one of glass, or of glazed porcelain, would altogether fail in dividing them, and, in that case, potato starch would simulate wheat starch. The number of slices which have been coloured blue by iodine, corresponding to the graduations of the glass-measure, indicate at once the relative proportion of the potato flour.

14. When flour is adulterated with *maize*, or *Indian corn* flour, or with *ground rice*, the best method of detecting it is by the microscope. The suspected flour should first be washed under a thin streamlet of water, or in a bason half filled with water, in order to separate the gluten, and a portion of the starch which deposits being examined before the microscope, or with a magnifying glass, fragments of an angular shape and semi-transparent will be observed, if maize or rice is present. Bread made with flour, containing a certain quantity of these substances, feels harsh and dry, and if the proportion of Indian corn is at all considerable, the flour has a yellow appearance, it feels coarse, and has, moreover, a peculiar sweet and caky flavour.

15. When wheat flour has been mixed with *bean flour*, the meal has a yellowish appearance, feels soft, and has a peculiar, bitter, or acrid flavour of beans.

16. To detect the presence of *bean flour*, Mr. Rodriguez proposed the following method, which is accurate. It consists in submitting the suspected flour to dry distillation in a stone retort, and collecting the distillate in a vessel containing water, which will be found to have acquired an alkaline reaction. If, on the contrary, the wheat flour is pure, the

water in which the distillate will have condensed will remain perfectly neutral. This alkaline reaction takes place when beans, pulse, or pea meal has been added to wheat flour.

17. *Another process* is the following :—

Take of the flour under examination, 300 grains.

„	Sand	„	„	300	„
„	Water	„	„	2	ounces.

Triturate the flour and the sand strongly for about five minutes in a Wedgewood mortar, and add the water gradually by small portions at a time, so as to form a homogeneous paste, which should then be diluted with the remainder of the water. On filtering, it will be observed, that the flour which contains bean flour, filters much more slowly, and remains milky. A portion of the filtrate should then be mixed with its own bulk of solution of iodine, prepared expressly for the experiment, exactly as was described before in speaking of potato flour.

18. The liquor filtered from pure wheat flour, being tested by the solution of iodine as above said, assumes a deep pink colour, but that which contains bean flour has a pink colour of a lighter hue, and is more permanent than the other.

19. *Detection and determination of chalk in flour.*—A given weight of the flour, for example, 500 grains, are to be mixed with about 2000 grains-measure of pure distilled water, and hydrochloric acid is added. If the flour contains chalk in the proportion of $1\frac{1}{2}$ or 2 per cent., or more, an effervescence will be observed, owing to the disengagement of carbonic acid. The mass is then thrown on a filter, the filtrate is exactly neutralized by ammonia, and tested with oxalate of ammonia, which will then produce a precipitate of oxalate of lime. The liquor is left at rest for a few hours, in order that the precipitate may settle well ; it is then collected on a filter, washed, carefully dried, and ignited. Ignition converts it into carbonate of lime (chalk), in which

state it is weighed. It is advisable, however, to redissolve the precipitated oxalate of lime in hydrochloric acid, and to reprecipitate it by oxalate of ammonia as before.

20. Bread made with flour, containing more than 4 per cent. of chalk, is spotted here and there with white marks, which are due to an agglomeration of small quantities of carbonate of lime.

21. Pure flour, of course, does not effervesce by treatment with hydrochloric acid.

22. The following process may serve to detect sophistications with earthy or such like matters. A portion of the suspected flour, 200 grains for example, is first well dried, incinerated, and then weighed. The residuum from pure flour should not exceed from 8 to 9 per cent. If more than this, the flour may be looked upon as adulterated.

23. The presence of *alum* in flour is detected exactly as in bread.—(See the article on *Bread*.)

24. The physical characteristics of wheat flour of good quality, are the following:—it has a dull white colour, somewhat inclining to yellow; it should exhibit to the eye no trace of bran, even when pressed smooth, either with the hand, or with a polished surface. It should have a homogeneous appearance, and not lose more than from 6 to 12 per cent. after drying it in a stove. The less it loses by drying the better it is.

FLOWERS OF BENZOIN.—See *Benzoic Acid*.

FLOWERS OF ZINC.—See *Oxyde of Zinc*.

FRANKINCENSE.—See *Benzoin*.

FUMING SULPHURIC ACID.—See *Sulphuric Acid of Nordhausen*.

GALENA.

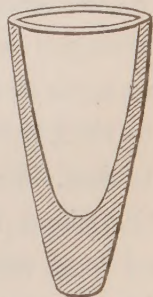
SULPHURET OF LEAD.

1. The ore from which lead is principally obtained is *galena*, or sulphuret of lead. Galena ordinarily contains silver; the whole of the precious metal passes into the lead from which it is separated afterwards, in the large way, by Mr. Pattenson's process, namely, by crystallization and cupellation. The other substances, most generally mixed with galena, are quartz, sulphate of baryta, iron, or arsenical pyrites, and blende (sulphuret of zinc).

2. The proportions of lead and of silver contained in galena may be determined in the wet and in the dry way, but the former seldom gives accurate results, is more tedious, and if the quantity of silver in the lead obtained is excessively minute, its estimation in the wet way cannot be at all relied upon.

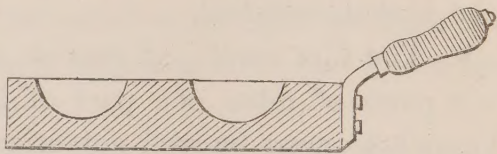
3. Determination of the amount of lead contained in galena in the dry way:—

4. For such an analysis the operator must be provided with a good air-furnace, which should be charged with coke, and lighted. When it is brought to as high a temperature as possible, a conical wrought-iron crucible should be plunged in the middle of the coke. The crucible generally employed is 4 inches high, 2 inches wide, and very thick at the bottom, as represented in the figure in the margin. The galena must be pulverized very carefully, for otherwise it will decrepitate under the first impression of the heat. When the crucible has attained a dark red head, 1000 grains of the pulverized galena are introduced into it; and when the mass of the pulverized ore has attained the temperature of the crucible, and therefore before it (the galena) has entered into fusion, the operator takes a stout iron wire, or rod, about the size of a quill, and about 3 feet



long, flattened at one end, so as to form a little spatula, which should always be kept in a perfectly clean state, and by means of which he gently stirs the mass in the crucible in order to expose all its surfaces to the action of the air for the purpose of roasting it, taking care, however, that the spatula does not become red hot, for in that case some of the galena would permanently adhere to it, and some of the lead would be reduced; to prevent this the spatula should be withdrawn from time to time, to allow it to cool, should it become too hot. This precaution, however, is almost superfluous, since the roasting is almost completed in one minute. Even though the spatula has not become red hot, a portion of galena is always found adhering to it, but it does not hold fast, and may be easily detached by scraping it with a knife, and should a small portion be still adhering to the edge of the spatula, which is generally the case, it may be readily removed by holding the spatula in a vertical position, moving it backwards and forwards, whilst pressing strongly enough on its edge to break and detach the said portions. All these little fragments must of course be returned to the crucible, which should then be kept covered, and the whole mass is allowed to attain a cherry red heat, when two large spoonfuls of the flux, described afterwards, must then be thrown into the crucible, which must now be brought to a full white heat. This will take about twelve or fifteen minutes. A piece of green wood, about three quarters of an inch in diameter, should be plunged in the crucible, its sides rubbed and scraped with it so as to detach the small particles which are adhering to them so that these small particles may be sunk into the mass now in fusion. The fused scories should also be slightly stirred with the piece of green wood, in order to precipitate any particle of lead which they might retain. The piece of wood should be kept moist, in order to prevent the scories from adhering to it. The crucible is then to be covered, and left in the fire for about two minutes longer, the fused mass being kept in full liquidity during that time. The crucible is then with-

drawn from the fire by seizing it with a pair of crucible tongs, the branches of which are horizontal, and the contents thereof are poured into an ingot mould of brass, here represented, in the following manner:—the crucible is brought with the tongs on the edge of the ingot mould, the tongs resting firmly on the said ingot mould; it is



then gently tilted, and the scories are carefully poured into one of the recesses of the ingot mould, until, in so doing, the operator begins to see the melted lead in the crucible. He then rakes up carefully the scories which still remain in the crucible, pushing and pressing them alternately on each side until they have become sufficiently stiff by cooling to allow of the molten lead being poured separately in the other recess of the ingot mould.

6. In order to be certain that the scories in the first recess retain no lead, the whole mass of the scories is returned into the iron crucible, which is then carefully scraped with the spatula of the stout iron wire above described, in order to collect all the particles which may be adhering to it. The operator then adds about half a spoonful more of flux, and the whole is replaced in the fire. When the mass is perfectly fused, which should be done as rapidly as possible, the crucible is again cleansed with the piece of green wood, and the whole is at once poured, scories and all, into one of the empty recesses; the molten lead percolates and collects at the bottom.

7. When the scories contain a certain quantity of lead, they, in cooling, contract, and a portion of the metal might thus be projected and lost. In order to avoid this accident, no sooner is the fused mass poured into the ingot mould, than it must be instantly turned upside down; the lead, by coming in contact with the cold mass of brass of the ingot mould, is at once solidified, and by upsetting immediately the ingot mould, it has no time to be refused by the hot scories from

which it is thus cleanly separated. The little button of lead thus obtained is flattened with a hammer in order to eliminate the film of scories which covers its surface, it is added to the rest of the lead obtained before, and the whole of the lead is then weighed.

8. The flux employed consists of three parts of red argol, two parts of nitre, one part of borax, $\frac{1}{2}$ part of fluor spar. The whole must be well pulverized and thoroughly mixed.

9. When the ore of lead is refractory, a small quantity of potash (about a spoonful) should be added for each 1000 grains of ore, and the roasting may then be dispensed with.

10. In this experiment a very high temperature is always required because, in that case, the iron crucible lasts longer since it needs not be left so long in the fire as would otherwise be necessary, and, moreover, if the temperature was not very high, a large quantity of oxyde of iron mixing with the mass would render it very infusible, and the operation would be spoiled.

11. In order to estimate the quantity of silver contained in the lead thus obtained, 500 grains of it are placed in a dry cupel of bone ash, and placed in the cupelling furnace, as described in the article on *Silver*. The metallic button of pure silver left on the cupel is then detached and weighed.

G A L L S.

GALL NUTS.

1. Galls are excrescences produced by the puncture of a small insect on the shoots and leaves of plants, and trees of various kinds, for the purpose of depositing its eggs. The best galls are those found on a species of oak (*quercus infectoria*) in Asia Minor, Syria, Persia, and other places; the best being those of Aleppo, which are tubercular and almost prickly on the surface, their size varying from that of a pea

to that of a large filbert. The best are small, heavy, hard, brittle, and of a bluish colour, they are called *blue galls*.

2. The *green galls* which, like the blue, are galls from which the insect has not escaped, are nearly as good as the blue galls, both are about one-third more effective than the *white galls*, which are the nuts gathered after the insect has escaped by eating its way out.

3. *White galls* are of a yellowish colour, perforated, light, and much less valuable.

4. The only fraud to which this important article is subject consists in dyeing the white galls, so as to simulate the colour of the blue galls, pass them off as such, and consequently obtain a higher price.

5. This sophistication, however, may be readily detected by the most casual observation, since all white galls are perforated, and much lighter than the blue or green galls; they are also much more easily broken, and they are then found to be hollow, the inside being full of a dry white powder, instead of being hard and compact, as is the case with the genuine blue and green galls. According to Sir H. Davy, 500 of galls contain—of tannin 130, of gallic acid 31, of mucilage 12, and of saline matter 12, the remainder consists of woody matter. The active principles of galls are taken up by water and by alcohol.

G A R A N C I N E.

ALIZARINE.

1. The garancine or alizarine met with in commerce may be tested in the same way as madder (see *Madder*), but its tinctorial power, and also that of madder, may be estimated by means of alcohol as follows:—

2. Take 1000 grains of madder, mix them with 1000 grains of concentrated sulphuric acid, and leave the whole to digest for a few hours. Mix the charcoal produced by the

action of the sulphuric acid with water, wash it on a filter, and then dry it at 212° Fahr. The charcoal is then pulverized and digested in the cold for two hours with alcohol at 36° Baumé, containing a little ether; the digestion is repeated three times with fresh portions of alcohol, the powder is then boiled three different times with 4000 grains of alcohol at 36°, and when it is no longer coloured by it, the liquor is evaporated to dryness by the water-bath; the weight of the residuum represents the proportion of red colouring matter contained in the madder.

4. As to garancine, it may be directly exhausted by alcohol, and the process is conducted as above said.

GAS.—See *Coal Gas*.

GERMAN SILVER.

PACKFONG. WHITE COPPER. ELECTRUM. TUTENAG.
 ALBATA. MAILLECHOR. ARGENTAN. TOMBAC.
 AMALGAMATED SILVER.

1. These alloys consist of nickel, copper, and zinc, in various proportions, with sometimes a little lead and iron. See the following table :—

	Good Maille- chor Argen- tan.	Ordinary.		Electrum.		Tutenag.		Pack- fong.	For Casting.	Tombac
Nickel ...	25	23.8	20.68	29.0	34.4	27.15	13.0	31.6	23.14	97
Zinc	25	18.9	24.13	19.4	19.9	27.00	25.0	25.4	18.52	2
Copper ...	50	59.3	55.19	51.6	45.7	45.85	57.4	40.4	55.55	"
Iron	"	"	"	"	"	"	9.0	2.6	"	"
Lead	"	"	"	"	"	"	"	"	2.83	"
Arsenic...	"	"	"	"	"	"	"	"	"	1
	100	100.0	100.00	100.0	100.0	100.00	100.0	100.0	100.00	100

2. The solder used for German silver consists of five parts of German silver and four parts of zinc. The alloy, when melted, is run into thin flakes, and then reduced to powder.

3. Under the name of *amalgamated silver plate*, forks, spoons, and other similar articles have lately been offered for sale. These utensils look certainly more beautiful than the common German silver, but instead of consisting of an alloy of pure silver, with a *new white metal*, as represented in the prospectus of the seller, and thus accounting for the high price of his wares, the alloy is nothing else than very common German silver, upon which a film of silver has been deposited by galvanic agency.

4. *Analysis of German silver.*—Take 50 grains of the alloy, and dissolve them in pure nitric acid (diluted). The solution being completed, and the excess of acid eliminated by evaporation, dilute the solution with a large proportion of water.

5. Observe that, whilst dissolving, the German silver, if *plated* with silver, will be unequally attacked, and the acid will dissolve the alloy more rapidly underneath, leaving the silver in a thin shell before the whole has dissolved. The operator should then examine this silver shell, and if it have a polished surface on both sides, the silver has been deposited by galvanic action; in the contrary case, the article examined has been plated in the usual way. This having been ascertained, and the whole having been dissolved, as we said, hydrochloric acid is added to the solution, in order to precipitate the silver, and the whole is moderately heated, in order to agglomerate the precipitated chloride of silver produced; it is then collected upon a filter, as small as possible, washed, dried with care, and ignited in a small porcelain crucible, the filter being burnt separately upon the cover of the crucible, with which the latter is subsequently to be closed. After fusion and cooling, the chloride of silver is weighed; 134 grains of chloride of silver represent 108 of

silver ; or, each grain of chloride of silver contains 0.75330 of silver.

6. The proportion of silver may also be determined by measure, that is, by means of a test-solution of hydrochloric acid, of a known strength. (See *Assay of Silver*.)

7. The liquid filtered from the chloride of silver produced, should next be treated by sulphuretted hydrogen, a stream of which should be passed through the liquor until it smells strongly of the gas. The black precipitate produced is separated by filtering, washed, and digested in strong nitric acid ; sulphuric acid is then added to the solution, which will precipitate the lead, if this metal be present. Supposing this to be the case, the whole should be evaporated to dryness, and a stronger heat applied towards the end, in order to evaporate the excess of sulphuric acid employed. The dry mass is now treated by water, which will leave the sulphate of lead in an insoluble state, it is then collected on a filter, washed, dried, slightly ignited in a porcelain crucible, and weighed. 152 grains of sulphate of lead contain 104 of lead ; or, each grain of sulphate of lead contains 0.73563 grains of lead.

8. To the liquor filtered from the sulphate of lead, or, if that metal be absent, to the nitric acid solution of the sulphuret produced by sulphuretted hydrogen, potash is now added, which will precipitate the copper in the state of protoxyde of copper ; the whole is boiled, the precipitated oxyde of copper is collected on a filter, washed with hot water, dried, ignited, and weighed immediately after cooling, the crucible being kept well closed, in order to avoid absorption of moisture. 40 grains of protoxyde of copper contain 32 of copper ; or, each grain of protoxyde of copper contains 0.79826 of copper.

9. The liquor which was filtered from the precipitate produced by sulphuretted hydrogen, should now be boiled, to expel the sulphuretted hydrogen, and when all odour of the gas has vanished, carbonate of soda is poured into the

liquor, and the whole is boiled for a few minutes, by which means the zinc and the nickel are thrown down. The precipitate should be collected on a filter and dissolved in acetic acid, which converts the nickel and the zinc into acetates of these metals. The solution should contain an excess of acetic acid. A current of sulphuretted hydrogen being now passed through the solution, the zinc will be precipitated in the state of sulphuret of zinc, whilst the nickel will remain in solution. The precipitated sulphuret of zinc is then separated by filtering, washed, and redissolved in hydrochloric acid, from which it is finally reprecipitated as carbonate of zinc, by a solution of carbonate of soda. This precipitate is then collected on a filter, washed, dried, and ignited. Ignition converts it into oxyde of zinc, in which state it is weighed. 40 grains of oxyde of zinc contain 32 of zinc; or one grain of oxyde of zinc contains 0.80128 of zinc.

10. The liquor filtered from the precipitated sulphuret of zinc contains the nickel, a portion of which metal is retained also in that from which both the zinc and nickel were precipitated by carbonate of soda, as described in the preceding paragraph. The two liquors should therefore be mixed, and the whole of the nickel contained therein should then be precipitated by means of a solution of caustic potash, which produces a bulky apple-green precipitate of hydrate of protoxyde of nickel. The whole should be heated, and the precipitate is then collected on a filter, washed with boiling water, dried, ignited, and weighed. 36 grains of oxyde of nickel contain 28 of nickel; or one grain of oxyde of nickel contains 0.78709 of nickel.

GIN.—See *Brandy*.

GLASS.

1. Glass is the generic name of the combination of silicate of potash, or of soda, with one or more of the following silicates, namely:—silicate of lime, of magnesia, of alumina,

of baryta, of iron. But, besides these, several other ingredients are introduced ; that in which silicate of lime is replaced by silicate of lead is called *crystal*.

2. The specific gravity of glass varies according to the substances of which it is composed.

3. *Bohemian glass* is a double silicate of potash, and of lime or alumina. Its specific gravity is 2.396. Its constituents are—

Silica	.	.	.	.	71.6
Lime	.	.	.	.	10.0
Potash	.	.	.	.	11.0
Magnesia	.	.	.	.	2.3
Alumina	.	.	.	.	2.2
Oxyde of iron	.	.	.	.	3.9
Oxyde of manganese	.	.	.	.	0.2

4. Bohemian glass is colourless, light, and, owing to the large proportions of silica which it contains, it is extremely difficult to fuse, on which account it is preferable to any other kind of glass for certain purposes, particularly for chemical operations.

5. It is also the only glass that can be *stained* red, for when the process of staining in that colour is attempted with any other, the glass softens long before the metallic oxyde employed to produce the red stain, has been brought to the fusing point. The ingredients for the manufacture of Bohemian glass are employed, it is said, in the following proportions :—

Quartz (hyalin) heated to redness, then quenched in cold water, and finely pulverized	.	.	.	.	.	100 parts
Calcined purified pearlash, of best quality	.	.	.	.	.	50 to 60 „
Calcined lime	.	.	.	.	.	15 to 20 „
Arsenious acid	.	.	.	.	.	$\frac{1}{4}$ to $\frac{1}{2}$ „
Nitre	.	.	.	.	.	1 „

6. *Crown glass* is also a silicate of potash and of lime,

chiefly employed for the preparation of optical instruments, but likewise for best window glass.

7. The specific gravity of crown glass is 2.487, and its constituents are as follow :—

Silica	.	.	.	.	62.8
Lime	.	.	.	.	12.5
Potash	.	.	.	.	22.1
Alumina	.	.	.	.	2.6
					100.0

8. *Crown glass* should be perfectly clear, free from streaks or bubbles, and colourless. The proportions of the above ingredients used for making the best crown glass are the following :—

Purified pearlash	.	.	.	250
Fine sand	.	.	.	300
Lime	.	.	.	33

9. *Window glass* is generally a double silicate of soda and of lime, the soda being obtained from a mixture of sulphate of soda and of charcoal, in the proportion of three parts of the first and one of the second. Its specific gravity is 2.642, and its composition is as follows :—

Silica	.	.	.	.	69.65
Lime	.	.	.	.	13.31
Soda	.	.	.	.	15.22
Oxyde of iron	.	.	.	.	1.82
					100.00

10. The proportions of the substances employed for making window glass, are the following :—

Sand	.	.	.	.	100 parts.
Dry sulphate of soda	.	.	.	.	44 „
Pulverized charcoal	.	.	.	.	8.5 „
Slaked lime	.	.	.	.	6. „
Collect	.	.	.	.	20 to 100 „

11. *Collect* is old broken glass.

12. *Plate glass* is a silicate of soda and of lime. Its specific gravity is generally 2.488, and its constituents are :—

Silica	.	.	.	.	75.9
Lime	.	.	.	.	3.8
Soda	.	.	.	.	17.5
Alumina	.	.	.	.	2.8
					100.0

13. Plate glass should be very clear, transparent, and free from streaks, knots, and bubbles; it is obtained by fusing together the following substances :—

Very fine white sand	.	.	300 parts.
Dry carbonate of soda	.	.	100 „
Lime slaked by exposure	.	.	43 „
Collect	.	.	300 „

14. The above proportions and ingredients are those used for the manufacture of plate-glass at St. Gobin, in France; the materials of English plate-glass are said to be—

Fine sand	.	.	300 lbs.
Soda	.	.	200 „
Lime	.	.	30 „
Manganese	.	.	32 ounces.
Cobalt azure	.	.	3 „
Fragments of good glass	.	.	300 lbs.

15. *Green bottle glass* contains a little potash or soda, but the proportion of lime, alumina, and oxyde of iron is considerable; a little manganese is present. Its specific gravity is 2.732. and its constituents are as follow :—

Silica	.	.	.	.	53.55
Lime	.	.	.	.	29.22
Potash and soda	.	.	.	.	5.48
Alumina	.	.	.	.	6.01
Oxyde of iron	.	.	.	.	5.74
					100.00

16. The green colour of this kind of glass is due to the presence of oxyde of iron which is reduced by the carbonaceous matter of the ingredients, and which forms a silicate of protoxyde of iron. The brown colour of some kinds of bottle glass is due to the presence of an intermediary oxyde of iron; and that which has a yellowish colour, such as the bottles in which Rhenish wines are contained, owes its colour to the presence of peroxyde of manganese and of oxyde of iron.

17. The mixture employed for making bottle glass in France, Belgium, and Germany, consists of—

Yellow sand . . .	100 parts
Kelp	30 to 40 „
Lexivated wood ashes	160 to 170 „
Fresh wood ashes . .	30 to 40 „
Yellow clay	80 to 100 „
Collect	100 „

18. *Crystal* is a silicate of potash and of lead, the manufacture of which requires careful attention in the choice and purity of the materials, and in their manipulation. The silica employed should be as free from iron and organic substances as possible, and it should be in very fine powder.

19. In order to ascertain the purity of the sand to be employed, it is best to expose it to a high temperature, in contact with the air, during which the iron which it may contain becomes peroxydized, and imparts a reddish brown tinge to the sand. The purest sand of course is that the colour of which is least altered, but it is almost impossible to meet with sand which contains no trace of iron, and which, consequently, remains unaltered by that treatment.

20. The carbonate of potash used requires, likewise, to be carefully purified, which is done by dissolving it in water and evaporating, in order to crystallize and separate the sulphates and chlorides which it contains; the carbonate of potash remaining in the mother-waters, is recovered by evaporating the liquor to dryness.

21. Carbonate of soda cannot be employed in the manufacture of crystal, because it imparts to the mass a greenish tinge, however pure the salt may be. This greenish colour is, in fact, one of the characteristics of soda-glass.

22. The lead employed for making the red lead used for the manufacture of crystal must be of the purest and best kind, for the presence of any other metal would be sure to impart a tinge to the crystal. The presence of oxyde of copper is especially to be guarded against. The constituents of crystal are—

Silica	56.
Lime	2.6
Potash	8.9
Oxyde of lead	32.5
	100.0

23. The proportions usually employed are the following :—

24. In glass pots, heated with coals and covered—

Pure sand	300 parts.
Red lead	200 „
Purified carbonate of potash	90 to 95.

25. In glass pots, heated with charcoal as on the continent :—

Pure sand	300
Red lead	200
Purified carbonate of potash	100
Fragments of good glass	300
Oxyde of manganese	0.45
Arsenious acid	0.60

26. The two latter substances are employed for the purpose of oxydizing certain impurities, and especially the iron.

27. *Flint glass* contains more oxyde of lead than crystal. Its sp. gr. is 3.6. It should be very homogeneous, without bubbles, and colourless. It is employed in optics; lenses of flint glass, combined with those of crown glass, form achromatic lenses.

28. The constituents of flint glass are :—

Silica	.	.	.	.	42.5
Lime	.	.	.	.	0.5
Potash	.	.	.	.	11.7
Alumina	.	.	.	.	1.8
Oxyde of lead	.	.	.	.	43.5

29. Other specimens, according to Professor Faraday, consist of—

Silica	.	.	.	51.93	—	48.24	—	44.30
Oxyde of lead	.	.	.	33.28	—	40.12	—	43.05
Potash	.	.	.	13.77	—	10.60	—	11.75
Alumina	.	.	.	0.47	—	0.58	—	0.50
Oxydes of iron, and of manganese	}	.	.	0.27	—	0.08	—	0.12
				99.72	—	99.62	—	99.72

30. The proportions of the materials employed in the manufacture of flint glass are as follow :—

Pure sand	.	.	.	300
Red lead	.	.	.	300
Potash	.	.	.	150
Nitre	.	.	.	10
Arsenious acid	.	.	.	0.45
Oxyde of manganese	.	.	.	0.60

31. We shall now describe the process of analyzing glass, and we shall suppose first, that the glass to be analyzed contains silica, alumina, lime, oxyde of iron, potash, and soda, that is to say, bottle glass.

32. Take 100 grains of the glass previously reduced into very fine powder, and mix it carefully with about 400 grains of dry carbonate of soda, also in very fine powder, put the mixture into a platinum crucible, or capsule, and maintain it in a perfectly fused state for about half an hour. When cold, place the crucible containing the fused mass in a wide porcelain capsule, and carefully pour an excess of dilute hydrochloric acid upon it, whereupon, all the oxydes, earths, and alkalies, as well as the silica, will be dissolved. Wash the crucible clean, and carefully evaporate the whole of the liquor, with whatever residuum it may contain, to dryness. When dry, increase the heat to above 500° or 600° Fahr., which will render the silica insoluble. The dry residuum must now be treated with acidified water, which redissolves the oxydes, but which leaves the silica in an insoluble state. The latter is collected on a filter, washed, dried, ignited, and weighed.

33. The liquor filtered from the silica is then treated by an excess of solution of ammonia, by which the peroxydes of iron and the alumina are precipitated, whilst the lime remains in solution in the state of chloride of calcium. The precipitates of peroxyde of iron and of alumina are separated by filtering, and washed. This being done, an excess of solution of caustic potash is poured on the washed precipitate, and the whole is boiled. The potash dissolves the alumina, but leaves the peroxyde of iron in an insoluble state; it is collected on a filter, thoroughly washed with boiling water, dried, ignited, and weighed. The liquor filtered from the peroxyde of iron, and which contains the alumina in solution (aluminate of potash) should now be decomposed by supersaturating it with hydrochloric acid, and carbonate of ammonia being poured into it, the alumina is precipitated; it is then collected on a filter, washed, dried, ignited, and weighed.

34. The liquor which was filtered from the precipitate of peroxyde of iron and of alumina, produced by ammonia, and

which contains the chloride of calcium in solution, should now be treated by oxalate of ammonia, which precipitates the lime in the state of oxalate of lime. This precipitate being collected on a filter, washed, and ignited, is then weighed as carbonate of lime. 50 grains of carbonate of lime represent 28 of lime ; or each grain of carbonate of lime contains 0.56292 of lime.

35. The determination of the quantity of potash and of soda contained in glass is more difficult. The process which gives the best results is that by treatment with hydrochloric acid. Brunner's apparatus, which obviates the necessity of the use of a platinum retort, is the most convenient. The operation should be performed as follows :—Take a fresh portion of the glass to be analyzed, previously reduced by levigation into exceedingly fine powder, weigh off 25 grains of it, put them in a platinum capsule, and drench it with water ; take now a flat-bottomed lead capsule, with a cover also of lead, about six inches in diameter, and two inches and a half high ; place in the middle of it a small ring of lead, which may be easily made by bending a strip of lead about one inch, or one inch and a half in diameter, and one inch and a half thick ; pulverized fluor spar should then be spread in the lead capsule, and concentrated sulphuric acid being poured upon it, the platinum capsule containing the pulverized glass, moistened with water, is immediately placed upon the ring of lead, and the leaden cover is placed over the whole. This being done, the heat of a small spirit lamp is applied to the lead capsule ; the hydrofluoric acid fumes evolved are absorbed by the water of the moistened and pulverized glass, and, re-acting upon the glass, liberate fluoride of silicium. This experiment should be carried under the hood of a chimney with a good draught, or in the open air. About two hours are required to complete the decomposition of the glass, during which time the mass should be now and then stirred, and moistened with a little water. When the decomposition is effected, the mass in the platinum

capsule should be treated with a sulphuric acid, and evaporated to dryness ; dilute sulphuric acid is then poured upon the dry mass ; this dissolves the potash, soda, alumina, oxyde of iron, and a trace of lime. The solution being now treated by carbonate of ammonia, the alumina, oxyde of iron, and lime are precipitated, and separated by filtering. The liquor filtered therefrom being evaporated to dryness and slightly ignited, the residuum, which consists of sulphate of potash and of soda, is weighed, in order to obtain their collective weight ; they are then redissolved by water, and a solution of chloride of barium is poured in, which converts the above sulphates into chlorides, and the white precipitate of sulphate of baryta, produced by the re-action, is separated by filtering. The filtrate is concentrated by evaporation, and an excess of solution of chloride of platinum is poured into it, which precipitates the potash in the state of double chloride of potassium and platinum ; the whole being carefully evaporated nearly to dryness, alcohol is poured upon it, the precipitate is collected on a filter, washed with weak alcohol, carefully dried at 212° Fahr., and it is then weighed. 247 grains of the double chloride of potassium and platinum represent 48 grains of potash.

36. When the glass submitted to analysis contains oxyde of lead, the pulverized mass, after fusion with carbonate of potash, as we described before, should be treated by nitric acid (instead of by hydrochloric acid) and evaporated to dryness, exactly as before mentioned, in order to render the silica insoluble ; the mass is then treated by water and thrown on a filter, in order to separate the silica. A current of sulphuretted hydrogen must now be passed through the liquor, filtered from the insoluble silica, until it smells strongly of the gas, the black precipitate of sulphuret of lead, which is thus produced, should be collected on as small a filter as possible, well washed and dried ; it should then be put into a glass-beaker along with the filter, and strongly fuming nitric acid cautiously poured upon it, in small portions at a

time, for the action is violent, and a portion of the mass might otherwise be projected; wherefore the glass-beaker should be kept covered with a capsule in order to guard against loss. The sulphuret of lead is thus converted into sulphate of lead by the oxydizing action of the nitric acid, and a few drops of sulphuric acid may further be added. The sulphate of lead produced is moderately heated, until acid vapours cease to be evolved, it is then ignited and weighed.

37. Or the sulphuret of lead precipitated may be treated by concentrated hydrochloric acid, which produces a disengagement of sulphuretted hydrogen, and the lead is then in the state of chloride. Nitric acid is then added, the whole is evaporated to dryness, the sulphate of lead so produced is ignited in a porcelain crucible and weighed; 152 grains of sulphate of lead represent 104 of lead.

38. If the glass contains magnesia, the pulverized glass, after having been fused with carbonate of soda, and subsequently treated by hydrochloric acid, evaporated to dryness, and the silica having been separated as before mentioned, a solution of sal ammoniac and an excess of ammonia are added, the oxyde of iron and the alumina are thus precipitated, but the magnesia is kept in solution by the ammoniacal salt contained in the liquor. The precipitate so produced is separated by filtering, and the filtrate is treated by oxalate of ammonia, which precipitates the lime in the state of oxalate of lime, which is separated by filtering. The liquor filtered from the oxalate of lime is now mixed with an excess of carbonate of potash and boiled for a long time, by which the magnesia is precipitated as carbonate of magnesia. In order to ascertain whether enough carbonate of potash has been used, the liquor should be heated until it no longer smells of ammonia, and then a little more carbonate of potash is added, which, if a smell of ammonia is reproduced, it is a proof that carbonate of potash has not been added in sufficient quantity. This is important, since the whole of the magnesia cannot be

precipitated so long as any of the ammoniacal salts in the liquor remains undecomposed. The carbonate of magnesia precipitated, as just said, is then collected on a filter, washed with hot water, and yet not too long, since carbonate of magnesia is not quite insoluble in water, though more so in hot than in cold water. The precipitate is then dried and ignited for some length of time, and then weighed as pure magnesia.

39. The precipitates of oxyde of iron, alumina, and oxalate of lime, above alluded to, should be treated as we indicated at the beginning, Nos. 33, 34.

GLASS OF ANTIMONY.—See *Sulphuret of Antimony*.

GLAUBER'S SALT.—See *Sulphate of Soda*.

GLUE.

1. Glue and size are made from the pieces of skin which are cut off by tanners as unfit for conversion into leather, or which are too small to be turned to any other account. The conversion of skins into glue or size is effected by boiling them in water, in large boilers or coppers provided with a grating at the bottom, and into which the pieces of skin inclosed in a large net, lifted and lowered down by a crane, are immersed. The conversion of skin into glue is known only as a fact, but is not as yet well understood, for glue or gelatine does not exist ready formed in the animal tissue.

2. In the pure state glue is colourless, transparent, hard, and extremely cohesive; this cohesion or *strength*, however, is less considerable in that which has been obtained from bones and cartilage, the strongest being that derived from skins, and especially from ox and cow-hides.

3. The glue of commerce has ordinarily a yellow or brown colour from the coagulated albumen, and other extractive matter which it contains.

4. When a concentrated solution of alum is mixed with melted glue, the latter becomes whiter, and it thickens, the tenacity of the glue being thereby apparently increased and its colour improved, so that glue made from skins of an inferior quality may thus compete *to the eye* with that made of the best materials. Alum, however, is always added to a certain extent to glue, and largely to size, in order to clarify the liquor from which these substances are obtained, before they are poured in the moulds or into the firkins. Alum has also the property of preventing the size from turning mouldy. The addition is therefore so far beneficial, but it should not be overdone. Alum may be estimated in glue, after incinerating it, in the same way as described in the article on *Bread*.

5. A superior description of size is employed by paper-makers and paper-stainers, it is a colourless article manufactured from hides which are macerated in water to incipient putrefaction; they are macerated in an aqueous solution of sulphurous acid, and then converted into size in the usual way.

GOLD.

1. The process generally employed for the analysis of most of the alloys of gold is cupelling, the air having no action on gold, even at the highest temperature, whilst copper, and most other metals with which it is alloyed, are, on the contrary, very easily oxydized when so treated.

2. Let us suppose, for example, that the sample to be analyzed is an alloy of gold and copper; for technical purposes the proportions of such an alloy may be determined simply by weighing off 10 grains of the compound, cupelling it with 30 or 40 grains of pure lead, and weighing the button of gold left in the cupel. The loss of course indicates

the quantity of copper contained in the 10 grains operated upon. The button of gold thus obtained, however, does not indicate correctly the quantity of gold, a small portion of copper or of lead being retained; and if silver be present as well, it remains, of course, united with the gold.

3. In order to obtain accurate results, the alloy of gold and copper should first be cupelled, at a moderate heat, with a certain quantity of silver and of lead, and the button thus obtained being then treated by an excess of nitric acid, the foreign metals are thereby dissolved, and the gold is left in the pure state. The quantity of silver added should be about three or three and a half times as much as that of the gold; for if the proportion of silver were less, the gold would shield the copper and the silver from the action of the nitric acid, whilst if, in larger proportion, the gold obtained would be in such a state of division as to be difficultly collected and washed. The heat employed for cupelling should be as low as consistent with the operation, in order that the litharge produced should carry as little gold as possible in the cupel. The quantity of lead used for cupelling should be increased with that of the copper present in the alloy, as shown in the following table:—

Gold per cent.	Gold in 10 grains.	Silver necessary for cupelling 10 grs. of alloy.	Lead necessary for cupelling 10 grs. of alloy.
100	10	30	10
90	9	27	100
80	8	24	160
70	7	21	220
60	6	18	240
50	5	15	260
40	4	12	340
30	3	9	
20	2	6	
10	1	3	

4. The above table shows that an alloy which contains 80 per cent. of gold, requires sixteen times its weight of lead

for cupelling, and therefore 10 grains of such an alloy will require 160 grains of lead, and 24 grains of silver.

5. Gold being neither volatile, nor liable to spirt in cooling, nor to be absorbed by the cupel, the cupellation requires less attention than that of silver, yet it should not be left in the muffle longer than is necessary, or else a small loss may take place.

6. In order to know what quantity of silver should be added to the alloy, the per centage in gold should first be approximatively determined before proceeding to the actual assay. This may be done by cupelling one grain of the alloy with 3 grains of silver and 10 grains of lead. The button obtained is then flattened with a hammer, and boiled for a few minutes, with about a quarter of an ounce of pure nitric acid. From the weight of the insoluble residuum, the per centage of the gold becomes thus approximatively known.

7. This being done, 10 grains of the alloy are accurately weighed and wrapped up in a piece of paper, with the requisite quantity of silver, corresponding to the per centage indicated in the table. A larger quantity than 10 grains should not be taken, for the analysis is less accurate when larger proportions of alloy are operated upon. The necessary quantity of lead indicated in the table, as corresponding to the approximative per centage obtained by previous experiment, is then introduced into the cupel whilst at a good red heat; and as soon as the lead, having fused, presents a clear and bright surface, the alloy and the silver are added. The rest of the operation is similar to that of cupelling silver (see *Silver*), taking care, however, to keep the heat as low as consistent with the cupelling, in order to guard against any gold being absorbed by the cupel.

8. When the button has cooled it is removed and hammered into a thin leaf upon a steel anvil, annealed, hammered again, and again annealed; after which it is rolled up and heated in a matrass, first for about twenty minutes, with about one ounce of pure nitric acid which should be diluted, for a strong acid might tear the little coil of alloy; the silver is thereby

dissolved, and the gold remains. When the action of the acid has ceased, it is decanted, pure nitric acid, somewhat stronger than the first, is poured upon the residuum, and the whole is boiled for about ten minutes more. The liquor is then decanted, and the residuum is repeatedly washed with distilled water. The washing must be continued so long as a white precipitate or turbidness is produced by testing with hydrochloric acid. The gold which remains retains the form which it had before treating it with nitric acid. In order to remove it from the matrass without breaking it, the matrass should be filled with water, and carefully turned upside down in a small hessian crucible; the gold, of course, falls to the bottom, and after having decanted the water, the crucible containing the little coil of gold is exposed to a red heat, in order to render it more compact, but which should not be high enough to fuse it. The weight of the gold thus obtained, multiplied by 10, gives the per centage of the gold in the alloy.

9. The loss indicates, of course, the quantity of silver.

10. If the operation has been carefully performed, the gold contains only traces of silver.

11. If the alloy was very rich, this increase is a little more, but is always trifling.

12. If, on the contrary, the alloy is very poor and contains a good deal of copper, this increase is not perceptible, because it is made up by the absorption of a little gold by the cupel.

13. In order, however, to avoid the increase of weight, which always takes place when the sample is very rich in gold, or is pure gold, the little coil should be carefully laminated, perfectly annealed, and treated three times with fresh nitric acid, for without this precaution 10 grains of pure gold would, after treatment, indicate 10.0025, 10.005 and even sometimes 10.01.

14. The process which we have described is known under the name of inquartation, and is employed only when the alloy under examination contains considerably more gold

than silver, for in such a case the silver is sheltered from the action of the nitric acid by the gold, and cannot be separated by that acid alone ; but when the proportion of the gold in the alloy is small, that is, when it does not exceed one third or one fourth of that of the silver, it may be treated by pure nitric acid without further addition of silver, and without cupelling, but it must be first hammered and laminated as before mentioned.

15. Another method proposed by Mr. Thomson is as follows :—Chloride of silver being decomposed by the metals which are eliminated by cupelling, and being converted by them into pure silver, the process consists in fusing 6 grains of the gold to be assayed with 15 grains of silver, from 8 to 12 grains of chloride of silver, and 50 grains of decrepitated chloride of sodium (common salt). The fusion is effected in a crucible and the heat is kept up until the whole of the gold has alloyed with the silver. The other foreign metals which were alloyed with the gold combine with the chlorine of the chloride of silver, and are eliminated ; a metallic button is thus obtained, which may then be treated in the usual way as described before. Mr. Watherston, in his "*Art of Assaying*," says that, "It has recently been found that gold of the quality of 12 carats or less, if alloyed with zinc instead of the proper quantity of silver, presents a colour very nearly equal to that of a metal at least $2\frac{1}{2}$ or 3 carats higher, or of 8s. or 10s. an ounce more value ; and the consequence has been that a large quantity of jewellery has been made of gold alloyed in this manner ; and the same has been purchased by some shopkeepers, very much to their own loss, as well as that of the public : inasmuch as a galvanic action is produced, after a time, upon gold so alloyed ; by means of which the metal is split into separate pieces, and the articles rendered perfectly useless. Gold chains, pencil-cases, thimbles, and locket, are the articles of which the public and the shopkeepers will do well to take heed, as those have, among some other things, been lately so constructed."

16. The purification of the gold of commerce may be effected as follows :—

17. Dissolve the gold in aqua regia, and pour a solution of protosulphate of iron into that of the gold which will then be immediately precipitated in the form of a brown or yellowish brown powder, which is metallic gold. The aqua regia employed to dissolve the gold should contain as little nitric acid in excess as possible, and should contain free hydrochloric acid. The best way is, first to evaporate the solution of gold in the water bath until it no longer emits acid fumes, then to dissolve it in water, and to add hydrochloric acid. The solution of the protosalt of iron is then poured into it, and the gold gradually falls down as just said. Protosulphate of iron precipitates the gold completely. The liquor may then be decanted and the precipitated gold is digested in hydrochloric acid, washed, and fused into a metallic button, by heating it in a crucible with nitre and borax.

GRAPHITES.—See *Black Lead*.

GREY AMBER.—See *Ambergrease*.

GREY COBALT ORE.—See *Cobalt Ores*.

GUANO.

1. Guano is the Peruvian name of the droppings of sea-fowls which are now dug out for exportation as a substitute or an adjunct to farm-yard manure.

2. Guano is a very complex compound, the most important constituents of which consist of posphates of the earths and of the alkalies, ammonia or ammoniacal salts, or compounds capable of being resolved into ammonia. Guano contains likewise sulphates and chlorides of alkalies, which have also a fertilizing power to a certain extent, but which are of considerably less value in this respect than the other constituents just alluded to.

3. Liebig, in his work on "*Chemistry, in its application to Agriculture and Physiology*," quotes the following analysis of guano by Bartels and Volckel.

	Sample from Liverpool.	Sample from Lima.
1. Muriate of ammonia	6.500	4.2
2. Oxalate of ammonia	13.351	10.6
3. Urate of ammonia	3.244	9.0
4. Phosphate of ammonia	6.250	6.0
5. Waxy substance	0.600	"
6. Sulphate of potash	4.227	5.5
7. Sulphate of soda	1.119	3.8
8. Phosphate of soda	5.291	"
9. Phosphate of magnesia and ammonia	4.196	2.6
10. Chloride of sodium	0.100	"
11. Phosphate of lime	9.940	14.3
12. Oxalate of lime	16.360	7.0
13. Alumina	0.104	"
14. Residuum insoluble in nitric acid	5.800	4.7
15. Loss, consisting of water, ammonia, and organic matter not estimated }	22.718	32.3
	100.000	100.0

4. The following analysis of a sample of guano from Bolivia is given by Dr. Ure as a type of that substance in the best state, (Supplement to Dr. Ure's "*Dictionary of Arts, Manufactures, and Mines*.)

SOLUBLE MATTER.

1. Urea	5.00
2. Sulphate of potash	7.90
3. Chloride of sodium	5.00
4. Biphosphate of ammonia	5.50
5. Oxalate of ammonia	0.60
	24.00

INSOLUBLE MATTER.

1. Silica	2.25
2. Subphosphate of lime	9.00
3. Phosphate of magnesia and ammonia	1.25
4. Urate of ammonia	15.27
5. Undefined azotized organic matter, affording with the 14 parts of uric acid by ignition with hydrate of soda, 17.05 parts of ammonia	41.73
	69.50

5. The mean specific gravity of that sample was 1.63.

"In consequence of the high price of guano," says Mr. Johnston,* "the great demand for it, and the ease with which the unwary farmer may be imposed upon, guano has been frequently adulterated with various substances, and to a great extent. Impositions even have been practised, by selling as genuine guano, artificial mixtures, made to look so like guano, that the practical man in remote districts is unable to detect it. A sample of such pretended guano, which had been sold in the neighbourhood of Wigtown, and had been found to produce no effect upon the crops, was lately examined in my laboratory, and found to contain, in the state in which it was sold, more than half its weight of gypsum, the rest being peat or coal ashes, with a little common salt,

* Elements of Agricultural Chemistry and Geology, by James F. W. Johnston. Published by W. Blackwood and Sons.

sulphate of ammonia, and either dried urine, or the refuse of the glue manufactories, to give it a smell. I could not satisfy myself that it contained a particle of real guano. This shows how important it is, that the farmer should possess some means of readily, and at a cheap rate, testing the costly manures he employs." And Mr. Johnston adds in a note.—“Four vessels recently sailed hence for guano stations, ballasted with gypsum, or plaster of Paris. This substance is intended for admixture with guano, and will enable the parties to deliver from the vessel, a nice-looking and light-coloured article. Parties purchasing guano, are very desirous of having it delivered from the vessel, as they believe they obtain it pure. The favourite material for the adulteration of guano, at the present moment, is umber, which is brought from Anglesea, in large quantities. The rate of admixture, we are informed, is about 15 cwts of umber to about 5 cwts. of Peruvian guano, from which an excellent looking article, called African guano, is manufactured.”—*Liverpool paper*.

6. In order, however, to ascertain the real value of guano as a fertilizing agent, it is not necessary to perform so elaborate an analysis as those above quoted, and to determine the nature and quantity of all its constituents; for such a purpose it suffices to determine in the sample—

7. 1st.—The proportion of water. 2nd.—The proportion of fixed alkaline salts. 3rd.—The proportion of sand or of earthy salts. 4th.—The proportion of ammonia, either in the free state or in the state of ammoniacal salts; also the proportion of ammonia which may be produced from the decomposition of the uric and ulmic acids and of other nitrogenized matter present in the guano.

FIRST OPERATION.

100 grains of the sample of guano are weighed off and placed in a counterpoised paper-filter. Concentrated sulphuric acid is then poured into a jar, and the filter containing the guano is suspended over the surface of the acid, by

means of threads fastened to a cork with which the jar must be closed air-tight, until the guano no longer diminishes in weight, which is ascertained by weighing it again and again, after three or four hours' suspension; the loss indicates the proportion of water.

8. [The remainder of the 100 grains which have thus been suspended over the concentrated acid are now put into a platinum capsule or crucible, and submitted to a low red heat, which should be continued until all the organic matter is completely incinerated and reduced to white ashes. The combustion of the organic matter is accelerated by stirring. The free ammonia, uric acid, and other nitrogenized and organic matters, are thereby decomposed or volatilized, and their collective quantity may be at once estimated from the loss sustained, which loss, deducting the amount of water first determined, should not be less than from 52 to 60 per cent. See, however, the remarks at the end of this article.]

SECOND OPERATION.

9. The proportion of the soluble and of the insoluble salts, &c., may be ascertained as follows :—

10. GENERAL EXAMINATION.—Take the ashes which were left after the ignition of the 100 grains of the guano under examination, and having weighed them as above directed, triturate and boil them in distilled water. A portion will be taken up by the boiling water, leaving a residuum insoluble in water.

11. The soluble salts taken up by the boiling water, may consist of sulphate of soda, chloride of sodium, (common salt,) phosphate of soda, &c., as above said.

12. The salts insoluble in the boiling water, may consist of phosphates of lime, of magnesia, oxalate of lime, alumina, sand, &c.

13. The soluble portion must then be separated from the insoluble one, by filtering, and after washing the insoluble

mass on the filter, and drying it, it is weighed ; the loss indicates, of course, the amount of the soluble salts, which in good guano should amount to at least from 5 to 10 per cent.

14. SPECIAL EXAMINATION.—The aqueous solution, filtered from the insoluble portion above alluded to, and which contains the soluble salts of alkalies, should now be measured into three equal portions.

15. *The first portion* being acidified with nitric acid, a solution of nitrate of baryta is added, until a precipitate ceases to be produced. This precipitate is sulphate of baryta ; the liquor containing it should be heated, in order to agglomerate it well, after which it is collected on a filter, washed, ignited, and weighed. This precipitate indicates, of course, the proportion of sulphuric acid contained in the sample of guano, in the state of soluble sulphates of alkalies. 117 grains of sulphate of baryta represent 40 grains of dry sulphuric acid, or 88 grains of sulphate of potash, or 72 grains of sulphate of soda.

16. In stating the results of the analysis, the amount of sulphuric acid found is taken as sulphate of lime, (supposing that base to be present,) and if there be more sulphuric acid than will form a sulphate with the lime, subsequently found, the rest is calculated and taken account of as sulphate of potash, and then as sulphate of soda.

17. To *the second portion* of the filtrate, solution of nitrate of silver is added, as long as a precipitate, or a turbidness is produced, the whole is then gently heated, in order to agglomerate the precipitated chloride of silver, which is then collected on a filter, washed, dried, fused in a porcelain crucible, and weighed. 144 grains of chloride of silver, represent 36 grains of chlorine, and, consequently, 60 of chloride of sodium, or 76 of chloride of potassium.

18. In stating the results of the analysis, the amount of chlorine is calculated as chloride of sodium, and the surplus as chloride of potassium.

19. *The third portion* is tested for phosphoric acid, in which it is determined in the state of perphosphate of iron, as follows :—Take a certain quantity of pianoforte wire, which must be equal to at least twice the weight of the phosphoric acid suspected to be present in the liquor, and dissolve it in pure and hot nitric acid. Mix this solution with that of the liquor under examination, and add an excess of ammonia. This produces a reddish-brown precipitate, which is a sign that the quantity of persalt of iron added is sufficient, for otherwise the precipitate would be white, whitish, or yellowish-white. Heat is applied, and after a little time, this bulky precipitate should be collected on a filter, thoroughly washed with hot water, and when completely dry, it is strongly ignited, and weighed. From the weight of the ignited perphosphate of iron, the quantity of the phosphoric acid in the solution is ascertained, by deducting from it the amount of the peroxyde of iron, which is known from the quantity of iron employed, the difference indicates the amount of phosphoric acid present in that portion of the filtrate, and consequently, in the sample of guano submitted to analysis.

20. Each grain of metallic iron employed gives 1.6309 grains of peroxyde of iron.

21. Each grain of basic perphosphate of iron ($2 \text{ Fe}_2 \text{ O}_3, 3 \text{ PhO}_5$) contains 0.42784 grains of peroxyde of iron, and, consequently, 0.57216 grains of phosphoric acid.

22. This method of determining the amount of phosphoric acid is accurate, but it requires great attention on the part of the analyst, for any loss which may happen during the operation bears altogether upon the phosphoric acid.

23. The liquors filtered from the precipitates produced in the three portions, as above said, should now be mixed together, and a small quantity of sulphuric acid, of hydrochloric acid, and of oxalate of ammonia should be added thereto, for the purpose of precipitating the excess of nitrate of silver, and of nitrate of baryta employed, and also any lime which may be present in the liquor. The precipitates

which are thus produced must be separated by filtering, and the filtrate is then evaporated to dryness, and ignited, in order to expel the ammoniacal salts. A little water should now be poured upon the ignited residue, just in sufficient quantity to redissolve it, and the solution being first acidified with a little hydrochloric acid, an excess of a solution of perchloride of platinum is poured into it, which precipitates the potash in the state of double chloride of potassium and platinum. Strong alcohol should be added, and the precipitate, having completely settled, may then be collected on a filter, washed with spirits of wine, carefully dried at 212° Fahr., and weighed.

24. Each grain of potassio-chloride of platinum (Pt Cl_2 , KCl) represents 0.19297 of potash, or 0.30541 of chloride of potassium. The rest of the filtrate contains only the soda.

25. The proportion of phosphoric acid present in the guano, in the state of soluble phosphate, may also be determined, by pouring in the liquor filtered from the ashes left after the ignition of 100 grains of the guano, an excess of ammonia, and then a solution of sulphate of magnesia, previously mixed with as much sal ammoniac as will prevent ammonia from producing a precipitate in it. This mixed solution of sulphate of magnesia and sal ammoniac, should be poured in the filtered liquor above mentioned, as long as a precipitate continues to be produced. The whole is then left at rest for about twelve hours, in order that the precipitate may settle well; it is then collected on a filter, washed with water containing some ammonia, as long as the filtering liquor is rendered turbid when tested by a solution of chloride of barium. The precipitate is then dried, submitted to an intense heat in a covered platinum crucible, and when cold, it is weighed.

26. Each grain of pyrophosphate of magnesia (2 Mg O , PhO_5) contains 0.63363 of phosphoric acid.

GUANO.

THIRD OPERATION.

27. GENERAL EXAMINATION.—The weighed portion of ashes which could not be dissolved in water, and which consists of the earthy salts and silica or sand as before said, should be digested at a moderate heat in dilute hydrochloric acid, which will dissolve the carbonates and phosphates of lime and of magnesia, and the sand (which is recognized by its grittiness) mixed perhaps with a little alumina, is left undissolved, and may be collected on a filter, washed, dried, ignited, and weighed. The proportion of silica in good guano, should never exceed from 3 to 4 per cent.

28. If, on pouring the hydrochloric acid on the insoluble residuum, an effervescence is produced, it is owing to a disengagement of carbonic acid, and indicates, generally, the presence of oxalate of lime in the guano, the oxalate having been converted into carbonate by ignition.

29. The insoluble residuum may not only consist of sand and alumina, as just said, but likewise of sulphate of lime, some samples of guano recently imported containing sometimes considerable quantities of this substance.

30. SPECIAL EXAMINATION.—To ascertain whether the insoluble portion contains sulphate of lime, the operator should pour upon it about 500 times its weight of pure distilled water, and leave it to digest for about twelve hours; sulphate of lime being soluble in 430 parts of cold water, and in 460 parts of boiling water, will be taken up, and as its solubility is increased by common salt and also by sal ammoniac, a little of either of these two substances had better be added. After having digested the residuum in water, as just said, the whole should be thrown upon a filter to separate the silica which may be identified by its grittiness. The filtrate should now be divided into two equal portions, and if one of these portions being treated with solution of chloride of barium, and the other portion with oxalate of ammonia, a

white precipitate is produced in both, it is owing to the presence of sulphate of lime. Chloride of barium should, in that case, be added to the first portion as long as a precipitate of sulphate of baryta continues to be produced. This precipitate, having well settled, is collected on a filter, washed, dried, ignited, and weighed. Each grain of sulphate of baryta contains 0.34372 of sulphuric acid, and, consequently, 0.58432 gr. of sulphate of lime.

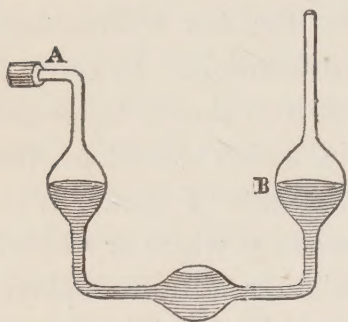
31. The liquor filtered in the first instance from the residuum, which was not dissolved by the hot hydrochloric acid, contains the phosphoric acid in solution. In order to separate it, a solution of perchloride of iron should be poured into it, and then an excess of ammonia, which should produce a reddish brown precipitate of perphosphate of iron. If the precipitate, instead of being reddish brown is white or whitish, it is a sign that the quantity of perchloride of iron employed is insufficient, and more of it must be added. The reddish brown precipitate should then be digested in hydrosulphuret of ammonia, by which it is converted into sulphuret of iron and phosphate of ammonia. After having left it to digest for a short time, the whole is thrown on a filter which retains the sulphuret of iron whilst the phosphate of ammonia passes through. After washing the precipitate, the phosphoric acid contained in the filtrate is precipitated in the state of double phosphate of magnesia and ammonia by means of a solution of sulphate of magnesia mixed with sal ammoniac, exactly as we described before. The amount of this phosphate in genuine guano should not be less than 14 per cent.

FOURTH OPERATION.

32. GENERAL EXAMINATION.—In the first operation we indicated how the amount of organic matter, of free and combined ammonia and other volatilizable matter, can be estimated; but if the operator wishes to estimate the quantity of free ammonia and that of combined ammonia, uric acid, &c., he should proceed as follows:—

33. SPECIAL EXAMINATION.—Take a fresh portion of the guano under examination, and expose it to the heat of a steam bath, in order to dry it well. Whilst this is doing, prepare a mixture of hydrate of soda and of quick lime (if not kept ready), by pulverizing in a mortar one part of recently ignited potash or soda, with two parts of pulverized caustic lime. This mixture may be kept ready prepared in perfectly dry and wide-mouthed bottles, with air-tight glass stoppers.

34. Take now a bulb condenser, as represented in the fig.,



and charge it with pure hydrochloric acid of specif. grav. 1.13. This is readily accomplished by plunging one of the extremities of the tube in the acid, and sucking at the other extremity, until the acid reaches the level indicated in the fig. The extremity A of the tube

passes through a cork, which must be soft, and of the very best quality.

35. Weigh off now 20 grains of the guano, previously well dried at a steam heat, as above said, and mix them with 200 grains of the alkaline mixture of soda-lime above alluded to. The mixing of the guano with the soda-lime should be effected in a slightly warmed and unglazed porcelain mortar. The mixture must now be introduced into a combustion tube of hard glass, about 16 or 18 inches long, and $\frac{3}{4}$ of an inch

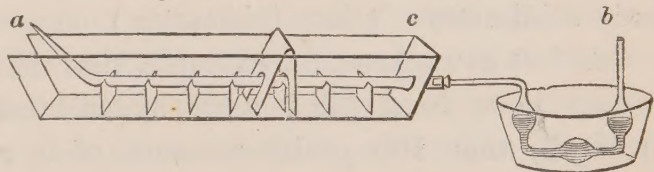


in diameter, represented in the adjoining figure. The mortar is rinsed with a little quantity of the soda-lime mixture, which

is also introduced into the tube with that already put there; a little plug of ignited asbestos should then be loosely placed over the whole, and the tube immediately connected with the bulb condenser above described, taking great care that the cork fits well, so that the connection may be air-tight. In order to make sure that the connection is air-tight

the operator should bring a red hot piece of charcoal to the empty portion of the first bulb, near the cork, which will rarify the air and expel a few bubbles of air from the apparatus ; or the operator may simply suck a few bubbles out of the apparatus. If, on cooling, or after suction, the liquid remains at a higher level in the furthest bulb B, it is a sign that the connection is sound. This being done, heat is applied to the combustion-tube by means of spirit-lamps, but much more conveniently still, by the furnace usually employed in organic analysis. The whole apparatus is represented in the next figure.

36. The tube is then gradually surrounded with red hot charcoal, by degrees shifting the screen *c* and adding coals as the combustion advances, so as to produce a gradual expul-



sion of the ammonia, accompanied by hydrogen and carburetted hydrogen, which two latter gases not being absorbable by the hydrochloric acid in the condenser, show the rate at which the combustion is going. The heat applied at first should be moderate, in order to prevent too rapid a disengagement of gas ; yet this disengagement should take place uninterruptedly, for otherwise, the acid might ascend into the tube and spoil the experiment. The disengagement should therefore proceed rather briskly than otherwise, the heat being gradually increased, until towards the end it has attained a good red heat. When the evolution of the gas ceases and the mixture in the tube has become *white*, the experiment is at an end. The point *a* of the combustion-tube should then be broken, and the ammonia which remains in the tube is expelled by sucking gently at the extremity *b* of the bulb condenser. The bulb condenser should then be disconnected and emptied into a porcelain capsule ; an excess of a solution of chloride of platinum is added to the acid-liquor, and the whole is slowly evaporated to dryness in a steam-bath. The

residuum should be treated with a mixture of two volumes of alcohol and one of ether, in order to dissolve the excess of chloride of platinum employed, and the ammonia chloride of platinum thus obtained being washed with the above mixture, until it passes colourless and neutral through the filter, is dried at 212° Fahr. and then weighed. 225 grains of ammonia chloride of platinum represent 14 of nitrogen, or 17 of ammonia ; or each grain of ammonia chloride of platinum represent 0.0763 of ammonia.

37. The quantity of ammonia may also be estimated by filling the bulb apparatus with a known quantity of hydrochloric acid of a known strength, and testing the acid of the bulb after the experiment, with a test-solution of ammonia, as in acidimetry. (See *Acidimetry*.)

38. Let us suppose, for example, that the bulbs of the condenser have been filled with hydrochloric acid of such strength, that 100 grains-measure of it represent, or are capable of saturating, 17 grains of ammonia, and diluted with a quantity of water, sufficient to fill up the bulbs. Let us suppose also, that after the experiment, the hydrochloric acid in the bulbs previously reddened by a small quantity of litmus, being tested with 1000 grains-measure of a solution of test-ammonia, spec. grav. 0.992 (1000 grains-measure of which contain exactly 17 grains of ammonia), it is found in pouring it from the alkalimeter into the hydrochloric acid under examination, that 89 divisions of the alkalimeter have been required to neutralize the acid. Since the acid in the bulbs, which should have saturated 100 divisions (1000 grains-measure) of the ammonia test-liquor, have required only 89 such divisions, it is evident that it has already neutralized as much ammonia from the guano as are represented by 11 divisions of the ammonia test-liquor, and that it therefore contained 1.87 of ammonia.

$$100 : 17 :: 11 : x = 1.87$$

39. The operator having experimented upon 20 grains of

guano, the 1.87 of ammonia must of course be multiplied by 5 to obtain the per centage $1.87 \times 5 = 9.35$ per cent. of ammonia, that is of available ammonia contained in the sample in the free state, or in the state of ammoniacal salts, or of nitrogenized organic matter capable of yielding the volatile alkali by spontaneous decomposition.

40. Amongst the constituents of guano shown in the analysis of that substance given at the beginning of this article, is urate of ammonia, which is one of the most valuable constituents of guano, but not always to be met with in it, for it exists only in the very best guano. The detection of that substance, and its quantitative determination is therefore extremely important. This may be accomplished by treating 100 grains of the guano with a solution of caustic potash, and boiling. The solution is then filtered, and a slight excess of dilute hydrochloric acid is then poured in, which produces a bulky crystalline precipitate, which is uric acid. It should be separated by filtering, washed with spirits of wine, and identified as uric acid by mixing it with nitric acid, and evaporating it carefully to dryness; the dry residuum should be crimson, and assume a bright purple colour by moistening it with ammonia. Each grain of uric acid represents 1.1012 of urate of ammonia.

41. The specific gravity of guano should be from 1.60 to 1.75, if above that, the guano contains more sand than should be.

42. From what we have said, guano may be considered as a mixture of ammoniacal salts and of earthy phosphates; the ammoniacal salts are more abundant in Peruvian than in African guano, but the latter contains more phosphates.

43. As a general rule, the purchaser of guano should choose it as dry as possible. Good guano, exposed at a heat of 212° Fahr. does not lose more than from 6 to 12 per cent. which includes a little ammonia. Bad guano, or that which is in a state of advanced decomposition, loses sometimes as much as 35, or even 40 per cent. of water.

44. A light colour, when the guano is genuine, indicates a less advanced state of decomposition, and guano is therefore better.

45. If it have a strong ammoniacal smell, it contains free ammonia ; and if it have no such smell, it should evolve it when mixed and triturated with a spoonful of slaked lime. Such guano contains *potential* ammonia, that is, ammonia which will eventually be produced from the spontaneous decomposition of uric acid and other nitrogenized matter. Potential ammonia exists only in good and dry guano.

GUINEA PEPPER.—See *Capsicum*.

GUM ARABIC.

1. Gum arabic exudes from several species of trees in Egypt and Arabia ; that from the *Acacia Arabica* is the best. It is in rounded pieces, of an irregular size, hard, brittle, semi-transparent, colourless, or of a slightly yellowish or brownish colour, due to the presence of foreign substances. Gum arabic is odourless, and has only a faint flavour. When pure, it is entirely soluble in water, but more rapidly in hot water. Its specific gravity varies from 1.31 to 1.48, or 1.515. In the dry state, gum arabic retains still 17 per cent. of water, which may be eliminated by pulverizing it and exposing the powder for a long time to a steam heat.

2. Gum Arabic is often adulterated with *gum senegal*, which has almost the same appearance, and altogether the same qualities as gum arabic ; but as gum arabic is always a little more expensive, the best pieces of gum senegal, that is, those which are small and of a light colour, dry, easily broken, and in fact, which resemble gum arabic most, are mixed with it, and sold as such. It is sometimes mixed also with common cherry-tree gum. The means of detecting this fraud are given in the article on gum senegal.

3. Gum arabic is often sold in a pulverized state ; the

gum sold in that state, and under that name (*pulvis acaciæ*) is a white powder, but which is frequently mixed with starch or flour, and in which generally the gum arabic is altogether replaced by gum senegal, or partly by pulverized cherry-tree gum. The adulteration with starch or flour, however, is very easily detected by putting a small quantity of the suspected gum into cold water, and stirring the whole for a while. The gum dissolves rapidly, whilst the starch or the flour falls to the bottom of the vessel.

4. The presence of starch and of flour may also be detected by boiling a small quantity of the suspected gum in water, and testing the mucilage, after it has become quite cold, with the tincture, or with an aqueous solution of iodine, which will immediately impart an intense blue colour to the mass.

GUM LAC.—See *Lac*.

GUM SENEGAL.

1. Gum senegal is produced by the *acacia senegalensis*, and has the same properties as gum arabic, the only difference being that gum senegal is in larger masses and of a darker colour, very hard, of a vitreous fracture; the lumps are often superficially covered with sand, which, however, is easily removed by washing them with water, and immediately drying them.

2. Gum senegal is often, like gum arabic, mixed with common cherry-tree gum, which resembles gum senegal. Common cherry-tree gum, however, is generally in irregular masses of a dark brown colour, difficult to break, and when thrown in water, they swell and separate in insoluble gelatinous clots; and if they be thrown on a filter, and the filtrate be evaporated, it will be seen that a small portion only has been taken up by the water. When pulverized, the presence of the common gum is recognized, because the

mucilage which the powder forms with water, instead of being homogeneous and syrupy, is more or less interspersed with gelatinous clots.

3. When pulverized gum is mixed with flour, or with starch, or with dextrine, the fraud is detected by means of iodine, as we said in the article on *Gum arabic*, to which the reader is referred.

GUM TRAGACANTH.

1. Gum tragacanth is produced by the *astragalus creticus*; it is met with in thin, opaque, white or yellowish, tough, flat strips of an irregular shape, or in threads, or in amorphous lumps, tasteless and odourless.

2. This gum has nearly the same properties as gum arabic or senegal, but it is partly insoluble in cold water, though entirely soluble in boiling water. One part of gum tragacanth forms as thick a mucilage as twenty-five parts of gum arabic.

3. Gum tragacanth, in the state just described, can hardly be adulterated; but in the pulverized state it is very often mixed with a multitude of other cheaper powders, more especially with gum senegal.

4. A mixture of pulverized gum tragacanth and gum senegal always forms with water a thinner mucilage than the same quantity of either of these gums alone. The following process is indicated, by M. Planche, for the detection of this fraud:—Make a mucilage of the suspected gum, and add thereto a few drops of alcoholic tincture of guaiacum, taking care to stir all the while. If the gum under examination contain any gum arabic, the mixture, in the course of a few minutes, assumes a fine blue colour, whilst it does not change colour if the gum tragacanth be pure. One-twentieth part of gum arabic can be thus detected.

5. We should remark, that only four or five drops of tincture of guaiacum should be employed for two drachms of

mucilage, and that when the quantity of gum arabic is very small, three or four hours must often elapse before the change of colour can be observed.

6. And, moreover, when rectified alcohol is poured in a clear and filtered mucilage of gum tragacanth, it produces only a few flakes, which swim about in the liquor, but do not impair its transparency, whilst if gum arabic is present, either a precipitate is produced in the liquid, or it becomes opalescent, according to the proportion of gum arabic which it contains.

GUN METAL.—See *Bronze*.

GUNPOWDER.

1. Gunpowder is essentially a mechanical but very intimate mixture of three substances, namely, saltpetre, charcoal, and sulphur, in various proportions, according to the use for which it is intended, and according to the country where it is manufactured. The following table indicates the composition of gunpowder in several countries:—

		Saltpetre.	Charcoal.	Sulphur.
England	Common powder	75.0	12.50	12.50
	Waltham Abbey Mills...	75	15	10
	Shooting powder }	78	12	10
		76	15	9
	Priming powder	65	15	20
France	National Mills.....	75	12.50	12.50
	Shooting powder	78	12	10
	Mining powder	62	18	20
America	Common powder	75	12.50	12.50
Prussia.....	do.	75	12.5	12.5
Russia	do.....	73.78	13.59	12.63
Austria.....	do.....	76	11.50	12.50
Spain	do.....	76.47	10.78	12.75
Holland	do.....	70.00	14.00	10.00
Sweden	do.....	75	9	16
Switzerland	do.....	76	14	10
China	do	75	14.40	9.60
Bavaria ...	do.....	75	12.5	12.5
Baden	do.....			

2. Under the influence of a sufficient degree of heat, the three constituents of gunpowder re-act powerfully upon each other, and disengage almost instantaneously an enormous quantity of gas, on which the dynamic effect of this compound depends. If the heat be communicated to the powder by a spark, the charcoal first catches fire, then the sulphur, and lastly the saltpetre is decomposed into potash, nitrogen, and oxygen. A small portion of the potash is decomposed by the carbon into potassium, water, and oxygen; the oxygen combining with the sulphur produces sulphurous acid, part of which escapes, whilst another portion combines with a part of the potash to form sulphite of potash, which is left as a residue. A portion of unconsumed sulphur remains also as a residue, but another portion combines with the potassium, and forms a residue of sulphuret of potassium. The carbon yields oxide of carbon and carbonic acid gasses; a portion of carbon is left as a residue. A portion of the carbonic acid combines with the potash, and gives a residue of carbonate of potash; the excessive heat produced by the combustion of the powder decomposes the nitric acid into nitrogen and oxygen, and converts into steam the water contained in the decomposed potash. The explosion carries off a portion of the residue in the form of smoke. We give below a diagram, indicating the products resulting from the decomposition of gunpowder by ignition. The re-actions indicated always take place; but, besides these, some other combinations are often detected, which result from the incomplete decomposition of the nitre, and from casual admixtures, or careless manufacture. The other compounds alluded to are sulphuretted hydrogen, carburetted hydrogen, sulphuret of carbon, sulphate of potash, and cyanide of potassium.

GUNPOWDER.

[illegible]

3. Aqueous vapour, though appearing amongst the gaseous products, is always in very small quantity, and its presence is owing to the property which charcoal powder possesses of absorbing moisture, on account of its porosity, and in consequence of which, gunpowder, even of the very best quality, and kept in the driest magazines, is never perfectly dry. The moisture penetrating the grains of powder, proportionately impairs its dynamic or ballistic effects, causes the saltpetre to effloresce at the surface of the grains, destroys the homogeneousness of the mixture, and disaggregates its constituents. The gunpowder which has been made with black charcoal absorbs less moisture, and this is the case also with large grained more than with small grained powder. In dry magazines, ordinary gunpowder contains from 0.5 to 0.6 per cent. of moisture, but if left exposed in damp places, it absorbs a much more considerable quantity of it. Large grained powder, and that which is damp, leave in the gun a thick coating, which augments at each round, and soon renders the gun so foul as to become useless until cleaned.

4. The temperature produced by the combustion of gunpowder is exceedingly high, and sufficient to melt gold and red copper; the gases produced by the combustion are thus enormously dilated, and, according to Gay Lussac, one volume of gunpowder produces about 2000 volumes of gas; but in order to obtain the fullest effect, the combustion must take place very rapidly, and therefore the dynamic effects of gunpowder depend not only upon the proportions of the substances employed, but likewise upon their intimate mixture, and on the physical state of the powder after being manufactured.

5. Gunpowder should be hard enough not to give a large quantity of dust by abrasion, for the dust lying compactly, impedes the rapidity of the inflammation. Good gunpowder should resist pressure between the fingers, and after spreading upon the back of the hand, it should leave no stain thereon.

The grains should have a slightly shining or glossy appearance, and be proportional to the use for which it is intended.

6. The grains of ammunition gunpowder should be angular, hard, and dry, they should be able to resist a moderate pressure, and give no dust when poured in the hand.

7. The grains of shooting gunpowder should be angular, hard, of uniform size, and glossy.

8. Miners' powder is similar to that used for cannon.

9. Good gunpowder, being spread upon a sheet of paper and inflamed, should burn rapidly with a flash, and should leave no appreciable residue on the paper; neither should it burn it.

10. Gunpowder has generally a dark greyish or brownish colour; a perfectly black colour indicates that either too much charcoal has been used, or that the charcoal was too hard. If the grains exhibit here and there white sparkling particles, they are due to an efflorescence of the saltpetre, and they are generally observable on powder which, having been accidentally wetted, has been re-dried.

11. When gunpowder does not contain more than seven per cent. of water, it may be rendered again perfectly good, by drying it; but when it contains eight, ten, or fourteen per cent. of water, as is sometimes the case, it should be re-manufactured. As, however, the gunpowder which has become wet may have lost a portion of its saltpetre, it is necessary to analyse it, in order to ascertain and, if necessary, to restore the loss. When damaged by sea water, it is no longer fit for use, but from such powder the saltpetre may be extracted.

12. *Analysis of gunpowder.*—The first thing to be done is to estimate the quantity of water which the powder contains; this is ascertained by taking 50 or 60 grains of the sample, reducing it into very fine powder, and submitting it to a temperature of 212° Fahr. in an oven, or stove heated by steam; or it may be dried in vacuo, over sulphuric acid, until it no longer loses weight. The loss indicates the quantity of water

The powder, after drying it as just said, should next be boiled in about six times its weight of water, and filtered. The insoluble residue, which consists of sulphur and of carbon, is collected upon a counterpoised filter, well washed with lukewarm water, until a drop of the filtrate, evaporated and heated to redness upon a strip of platinum foil, leaves no residue; the insoluble portion on the filter is then dried at 212° Fahr. and weighed. The loss indicates the quantity of nitrate of potash contained in the powder, and which the water has dissolved. The quantity of nitrate of potash, however, may be directly estimated by evaporating the filtrate to dryness, fusing the dry residuum by a gentle heat, and weighing it as nitrate of potash.

13. Yet the residue of saltpetre thus left, ordinarily contains some chloride of sodium, and in order to ascertain its quantity, the dry residuum should be weighed, as just said, and then redissolved in water; a solution of nitrate of silver being now poured into the liquor, will produce a white precipitate of chloride of silver, which may be collected on a filter, washed, dried, carefully ignited in a porcelain crucible, and weighed; 134 grs. of chloride of silver represent 60 grs. of chloride of sodium, or each grain of chloride of silver represent 0.407 of chloride of sodium. The quantity of chloride of sodium may also be determined by pouring into the above solution a portion of test-liquor of nitrate of silver, as described in the article on silver, to which the reader is referred.

14. The quantity of *sulphur* and of *carbon* may now be estimated in various ways:—

15. The insoluble residue, which was left after having exhausted the powder with water, is weighed, and then introduced into a tube provided with two bulbs; a stream of dry hydrogen gas should then be passed through it, and when the stream of hydrogen gas is in full activity, the bulb which contains the mixture is heated by means of an argand spirit lamp. The sulphur volatilizes and condenses in the

other bulb. When the whole of the sulphur has volatilized, the tube is allowed to cool, the stream of hydrogen gas being kept up until cold. The tube must then be cut with a file between the two bulbs, and the bulb containing the carbon is weighed. After deducting the weight of the glass, the difference gives the proportion of sulphur.

16. This method, however, is not very accurate; it is better and simpler to take 20 grains of the powder to be analyzed, previously reduced into very fine powder, and to mix it with its own weight of pure carbonate of potash or of soda, an equal quantity of nitrate of potash, and 80 grains of common salt. The whole should be intimately mixed and heated in a platinum crucible. As the mass begins to burn, the sulphur is converted into sulphuric acid, which combines with the potash. After combustion, the fused mass, which should be white, is dissolved in water, acidified by hydrochloric acid, or by nitric acid, which decomposes the excess of carbonate of potash, and also the nitrate of potash produced during the reaction; the whole is filtered, and the sulphuric acid is precipitated in the state of sulphate of baryta by means of a solution of chloride of barium, or of nitrate of baryta. The sulphate of baryta should then be collected on a filter, washed, dried, ignited, and weighed. 117 grains of sulphate of baryta represent 16 of sulphur, or each grain of sulphate of baryta represents 0.13747 of sulphur.

17. The respective quantities of saltpetre and of sulphur being now known, the difference indicates the proportion of the carbon.

18. According to Pelouze, the sulphur and carbon may be separated in the following manner:—

19. The insoluble portion which was left after having washed the saltpetre off, is treated by sulphite of potash, which dissolves the sulphur and becomes converted into hyposulphite of potash, leaving all the carbon in an insoluble state. It has therefore only to be collected on a counterpoised

filter, dried, and weighed. The solution of hyposulphite of potash should then be treated by hydrochloric acid, which precipitates all the sulphur which had been taken up, and which may be likewise collected on a filter, washed, dried, and weighed.

HAMBURGH WHITE.—See *Carbonate of Lead*.

HARTSHORNE (SPIRITS OF).—See *Ammonia*.

HEMATITE.—See *Iron Ores*.

HONEY.

1. Honey, as is well known, is a saccharine substance produced by the bee, of a semi-solid consistence, white, yellow, or brown, and sometimes of an aromatic taste; brown honey has generally an acrid, disagreeable flavour.

2. The best way of purifying honey is the following:—Dissolve the honey to be purified in its own weight of water, and boil the whole four or six times, without skimming. It should then be removed from the fire, and after cooling, it is poured upon linen strainers previously covered with fine and well washed white sand, about one inch thick. The solution of honey which filters through has then the colour of white wine, the sand on the strainers is rinsed with cold water, and the liquor is finally evaporated to the consistence of syrup.

3. Honey is sometimes adulterated with chalk, but more often with flour, or with syrup of potato-sugar (glucose).

4. These sophistications are easily detected and estimated by dissolving a given weight of the honey in cold water; the chalk or other insoluble substances will settle at the bottom, and may be readily separated by decantation; in this way the chalk and the flour will settle, the chalk, of course,

falling first. If the addition of hydrochloric acid produces an effervescence it indicates the presence of chalk; if solution of iodine imparts a blue colour, it is owing to the presence of starch or flour.

5. If potato-sugar is present in the honey, it may be detected by the processes which have been described in the article on *sugar*.

6. Honey which has been kept more than a year, or which has become of a syrupy consistence, or of an acidulous or pungent taste, should be rejected. It is with the view of shielding this deterioration that flour or starch is often mixed with it. When honey which has been sophisticated in this manner is heated, it liquefies at first, but on cooling it becomes solid and tough.

HYDRAULIC CEMENTS.—See *Lime*.

HYDRAULIC MORTARS.—See *Lime*.

HYDRIODATE OF POTASH.—See *Iodide of Potassium*.

HYDROCHLORIC ACID.

CHLORHYDRIC ACID. MURIATIC ACID. SPIRIT
OF SALT.

1. Hydrochloric acid is a combination of hydrogen and of chlorine. Hydrochloric acid is a gas, produced by the action of sulphuric acid upon common salt, which gas, when condensed in water, constitutes the liquid hydrochloric, or muriatic acid of commerce.

2. Commercial hydrochloric acid is a liquid of a yellow colour, of specific gravity 1.16 or 1.17, of a pungent, suffocating odour, intensely acid, and emitting white fumes in the air, especially if the air be damp. It is completely volatilized by heat. Pure hydrochloric acid is perfectly colourless.

3. As the specific gravity of hydrochloric acid is often arti-

ficially increased by the fraudulent addition of certain salts, the specific gravity is no criterion of its genuineness or strength, except it be known that the acid is pure. The presence of fixed salts, however may be summarily ascertained, by evaporating to dryness, a certain quantity of the acid under examination, which will leave the salts as a dry residuum, the relative proportion of which may at once be ascertained by weighing.

4. The proportion of real acid contained in a given sample may be correctly estimated by determining the saturating power. The manner in which this can be accomplished has been described in the article on acidimetry; that is to say, by using a test-liquor of ammonia, or of carbonate of soda of a known strength, or by ascertaining the quantity of carbonate of lime which may be required to saturate the acid. This may be done as follows:—take a given weight of the acid to be examined, for example, 100 grains, pour them into a somewhat large glass beaker, and dilute them with two or three times their weight of water. Take now a lump of white marble, more than sufficient to saturate the acid, weigh it accurately, and immerse it into the diluted acid in the glass-beaker. An effervescence immediately takes place, and the lump of marble should be left in the acid until the effervescence has completely ceased; the lump of marble is then withdrawn, washed, dried, and weighed again; the difference indicates, of course, the quantity dissolved. Now, since 37 grains of pure hydrochloric acid can saturate 50 of carbonate of lime, (marble,) it is clear, that if the 100 grains of hydrochloric acid tested have dissolved, for example, 45 grains of carbonate of lime, the acid contained 33.3 grains per cent. of real acid, or 84 per cent. of hydrochloric acid of sp. gr. 1.20. Such an acid should have a specific gravity of 1.17.

5. When, however, the acid is known to be pure, which may be ascertained as described further on, its strength may be determined by its density, as shown in the following table by Dr. Ure, which we reproduce here.—

Acid of 1.20 in 100.	Specific Gravity.	Chlorine.	Muriatic Gas.	Acid of 1.20 in 100.	Specific Gravity.	Chlorine.	Muriatic Gas.
100	1.2000	39.675	40.777	50	1.1000	19.837	20.388
99	1.1982	39.278	40.369	49	1.0980	19.440	19.980
98	1.1964	38.882	39.961	48	1.0960	19.044	19.572
97	1.1946	38.485	39.554	47	1.0939	18.647	19.165
96	1.1928	38.089	39.146	46	1.0919	18.250	18.757
95	1.1910	37.692	38.738	45	1.0899	17.854	18.349
94	1.1893	37.296	38.330	44	1.0879	17.457	17.941
93	1.1875	36.900	37.923	43	1.0859	17.060	17.534
92	1.1857	36.503	37.516	42	1.0838	16.664	17.126
91	1.1846	36.107	37.108	41	1.0818	16.267	16.718
90	1.1822	35.707	36.700	40	1.0798	15.870	16.310
89	1.1802	35.310	36.292	39	1.0778	15.474	15.902
88	1.1782	34.913	35.884	38	1.0758	15.077	15.494
87	1.1762	34.517	35.476	37	1.0738	14.680	15.087
86	1.1741	34.121	35.068	36	1.0718	14.284	14.679
85	1.1721	33.724	34.660	35	1.0697	13.887	14.271
84	1.1701	33.328	34.252	34	1.0677	13.490	13.863
83	1.1681	32.931	33.845	33	1.0657	13.094	13.456
82	1.1661	32.535	33.437	32	1.0637	12.697	13.049
81	1.1641	32.136	33.029	31	1.0617	12.300	12.641
80	1.1620	31.746	32.621	30	1.0597	11.903	12.233
79	1.1599	31.343	32.213	29	1.0577	11.506	11.825
78	1.1578	30.946	31.805	28	1.0557	11.109	11.418
77	1.1557	30.550	31.398	27	1.0537	10.712	11.010
76	1.1536	30.153	30.990	26	1.0517	10.316	10.602
75	1.1515	29.757	30.582	25	1.0497	9.919	10.194
74	1.1494	29.361	30.174	24	1.0477	9.522	9.786
73	1.1473	28.964	29.767	23	1.0457	9.126	9.379
72	1.1452	28.567	29.359	22	1.0437	8.729	8.971
71	1.1431	28.171	28.951	21	1.0417	8.332	8.563
70	1.1410	27.772	28.544	20	1.0397	7.935	8.155
69	1.1389	27.376	28.136	19	1.0377	7.538	7.747
68	1.1369	26.979	27.728	18	1.0357	7.141	7.340
67	1.1349	26.583	27.321	17	1.0337	6.745	6.932
66	1.1328	26.186	26.913	16	1.0318	6.348	6.524
65	1.1308	25.789	26.505	15	1.0298	5.951	6.116
64	1.1287	25.392	26.098	14	1.0279	5.554	5.709
63	1.1267	24.996	25.690	13	1.0259	5.158	5.301
62	1.1247	24.599	25.282	12	1.0239	4.762	4.893
61	1.1226	24.202	24.874	11	1.0220	4.365	4.486
60	1.1206	23.805	24.466	10	1.0200	3.968	4.078
59	1.1185	23.408	24.058	9	1.0180	3.571	3.670
58	1.1164	23.012	23.650	8	1.0160	3.174	3.262
57	1.1143	22.615	23.242	7	1.0140	2.778	2.854
56	1.1123	22.218	22.834	6	1.0120	2.381	2.447
55	1.1102	21.822	22.426	5	1.0100	1.984	2.039
54	1.1082	21.425	22.019	4	1.0080	1.588	1.631
53	1.1061	21.028	21.611	3	1.0060	1.191	1.224
52	1.1041	20.632	21.203	2	1.0040	0.795	0.816
51	1.1020	20.235	20.796	1	1.0020	0.397	0.408

6. Commercial hydrochloric acid is occasionally sophisticated, as we said, but, it is moreover, contaminated generally by various substances, the presence of which it is sometimes important to know how to detect. For example, it ordinarily contains all the salts which existed in the water which has been employed for condensing the gas, and likewise sulphurous and sulphuric acids, more or less ; perchloride of iron ; sometimes also, a little arsenious, or arsenic acids, nitric acid, and some free chlorine.

7. The presence of sulphurous acid is due to the action of the sulphuric acid upon the organic matter contained in the common salt employed in the manufacture of hydrochloric acid, but it is more especially on the Continent that this contamination is met with ; for common salt being there subject to a fiscal tax, from which that salt only is exempted which is employed for manufacturing purposes, the government require that such salt should be mixed with tar or coal dust. In Great Britain sulphurous acid is found in hydrochloric acid when it has been manufactured from the salt which comes from the cod fisheries. Sulphurous acid, however, may also proceed from the bisulphate of soda which is produced by the action of the sulphuric acid upon the salt, and which, being decomposed by the heat to which the retort is submitted, especially towards the end, is transformed into neutral sulphate of soda, sulphurous acid, oxygen, and anhydrous sulphuric acid.

8. However this may be, the presence of *sulphurous acid* is easily detected, by diluting a small portion of the hydrochloric acid with water, and adding *an excess* of chloride of barium, in order to precipitate the sulphuric acid which may exist in the acid ; this precipitate is separated by filtering, nitric acid is added to the filtrate, and the whole is then boiled. The sulphurous acid which may be present in the liquor, being thus oxydized by the nitric acid, is thereby transformed into sulphuric acid, which, combining with the excess of chloride of barium in the liquor, produces again a

white precipitate of sulphate of baryta, which may be separated by filtering, and from which, after washing, drying, and ignition, the quantity of sulphurous acid may be estimated ; 117 of sulphate of baryta represent 32 of sulphurous acid. If the proportion of sulphurous acid is considerable, it may be detected by its odour, (that of burning sulphur.)

9. The presence of *sulphurous acid* in hydrochloric acid may also be detected by means of a solution of permanganate of potash. For the preparation of permanganate of potash, see the article on *Nitre*. The process is as follows :—The acid in question is first diluted with water, and a few drops of the solution of permanganate of potash are poured into it. If the green colour of the permanganate is completely destroyed sulphurous acid is present, for otherwise the solution would assume, for a certain length of time, a red or pink tinge.

10. The presence of *sulphurous acid* may also be detected by passing a current of sulphuretted hydrogen through the hydrochloric acid, for in that case a milky white precipitate of sulphur is produced. If the precipitate so produced is yellow, *arsenious* or else *selenic acid* may be suspected.

11. But, according to Messrs. Fordos and Gelis, the smallest traces of *sulphurous acid* in hydrochloric acid may be detected as follows :—Dissolve a little zinc in the acid under examination, and pass the hydrogen gas which is evolved through a solution of subacetate of lead ; or, better still, through one of oxyde of lead in caustic potash ; a black precipitate of sulphuret of lead will then be produced.

12. The presence of *perchloride of iron* is easily detected by supersaturating the hydrochloric acid under examination with ammonia, which will precipitate the peroxyde of iron in the shape of flakes of a reddish-brown colour, either immediately, or, if in trifling quantity, after a little time.

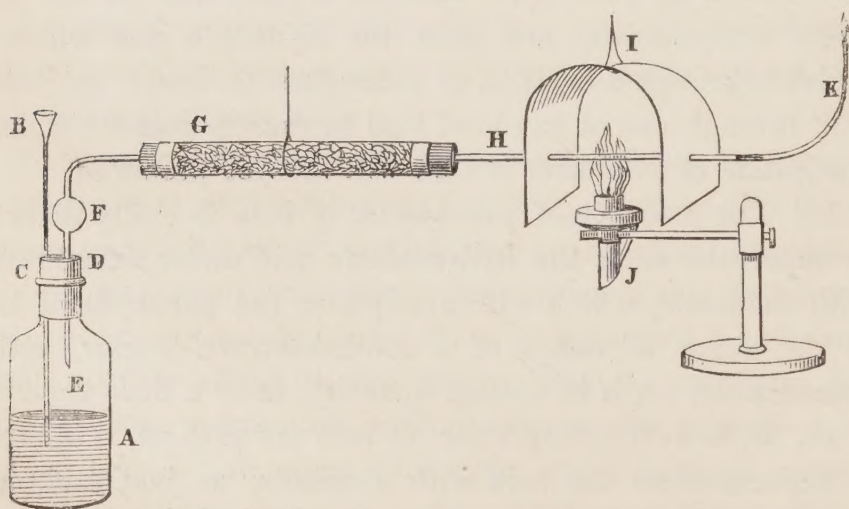
13. If, however, only traces of iron are present, it is better to supersaturate the acid with ammonia, as just said, and then to add hydrosulphuret of ammonia, which will precipi-

tate the iron in the state of black sulphuret. The yellow colour of the commercial acid is generally, though not always, due to the presence of iron, but it may be also derived from contamination with organic matter, for example, from the lute with which the carboys containing it are closed, and portions of which accidentally fall into it. The presence of organic matter is readily detected, by evaporating a few drops of the acid to dryness, a carbonaceous residuum will then be left.

14. The presence of arsenious acid is detected by Marsh's apparatus.

“ *Marsh's Apparatus.*—This instrument is grounded upon the property which nascent hydrogen has of combining with arsenic, with which it forms arseniuretted hydrogen, from which arsenic can be separated, as will be described.

The apparatus we have represented here, is a modification of M. Marsh's original apparatus, whereby several sources of error and inconvenience are avoided, whilst, at the same time, it is rendered much cheaper, since it may at once be made with the bottles and tubes which are always to be found in the laboratory.



A is a bottle into which the acid solution to be examined for arsenic is put together with pieces of pure zinc.

B is a glass funnel passing through the cork C, and plunging in the liquid to be examined.

C is a cork perforated with two holes for the introduction of the glass funnel B, and the tube D.

D is a glass tube bevelled at the end E, and to which a bulb F. has been blown, in order that any water which may have escaped with the gas being condensed may readily fall back into the flask or bottle A.

E, bevelled end of the tube D.

F, bulb blown in the tube D, and into which the moisture of the gas is condensed.

G, larger tube filled loosely with asbestos or cotton, in order to sift the gas as it passes through, thus preventing any particles of zinc or other metals from being carried farther by the gas.

H, tube of hard glass inserted in the larger tube G, and through which the gas ultimately passes, it is drawn into a point at K, for the purpose of inflaming the gas there.

I is a sheet of copper through which the tube H passes, and the object of which is—

First. To support the tube, as it might bend by being heated with the spirit-lamp J.

Secondly. To reflect the heat of the lamp on that part of the tube.

Thirdly. To keep the portion of the tube before and after its entrance in the copper sheet, sheltered from the heat, and therefore cool.

J, spirit-lamp.

K is the end of the tube H drawn to a point.

The apparatus being thus disposed, and containing the pieces of pure zinc in bottle A, some water should be poured in sufficient quantity to stop the end of the glass funnel B,

and then the hydrochloric acid under examination is introduced. Hydrogen is generated, which is allowed to escape for some time, so that the whole apparatus is filled with it. It may then be inflamed at the end, and a piece of glass, or china, or mica, being introduced into the flame at the end K, will show whether the zinc employed is pure as, if so, the piece of glass, or china, or mica, will remain spotless.

As the zinc employed for the apparatus must of course contain no arsenic, the following method of purifying it for the purpose has been proposed by M. Michelet :—

Melt some commercial zinc, and when very hot pour it out into a deep pail of water. Gather the zinc thus granulated, and if not in sufficiently small pieces, break the larger bits in a mortar, and place them in alternate layers with one quarter of their weight of saltpetre into a Hessian crucible, taking care to begin with a layer of saltpetre and terminate with a layer of zinc. Heat now the crucible, and when the deflagration and fusion will have taken place, remove the scories and run the zinc in an ingot mould ; it will be found to be perfectly pure.

Caution.—It is necessary to wait some little time before inflaming the gas at K, in order that the apparatus may contain nothing but hydrogen, as if atmospheric air was still in it an explosion might take place, which would break the apparatus.

Having thus ascertained that the zinc and materials employed are pure, the hydrochloric acid being first diluted, so that it be only moderately acid, is to be introduced into the bottle A, by means of the funnel B.

The gas escaping at K may now be inflamed, which, if nothing but pure hydrogen is escaping, will burn with the ordinary blue flame peculiar to that gas ; but if arsenic be present, the flame will be whitish.

If a piece of glass, china, or mica, being held in the flame, remains spotless, it is a sign that nothing but hydrogen is escaping ; but if, on the contrary, the piece of glass, or china, or mica, being thus held in the flame, a deposit is formed thereon, of a white or brown colour, it is either metallic arsenic, or arsenious acid, or oxyde of antimony ; thus proving that the acid under examination contains arsenic.

To identify arsenic, the spirit-lamp J is to be lighted ; whereupon the gas, in passing through the tube thus exposed to a red heat, will be decomposed, and the result will be that the metal of the arseniuretted hydrogen will be thereby reduced.

If the metal reduced by the heat is deposited in the tube, at a certain distance beyond the point at which the tube is heated, and if heat being applied again to that part where the deposit has taken place, this deposit, by being heated again volatilizes and goes beyond the place thus heated, to be deposited at another portion of the tube, and so on, then the compound contains *arsenic*.

This being ascertained, that part of the tube K drawn into a point may be broken, and the disengagement of gas may be left to take place, until the whole of the arsenic will have escaped in the shape of arseniuretted gas.

Caution. — When the compound contains arsenic, the disengagement of the arseniuretted hydrogen produced must never be suffered to take place in the apartment, but in the flue of the chimney, and great care is to be taken not to breathe any portion of it, as it is an exceedingly deleterious gas. Gehlin, a German chemist of repute, died from having inhaled a small portion of it. He was experimenting upon this gas, and, suspecting that the apparatus was leaking, he applied his nose to discover where the escape was, when in the course of an hour

he was seized with violent vomiting, shivering, extreme debility, and he died, though the quantity he breathed must have been exceedingly small.

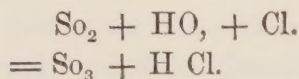
15. If *nitric acid* be present, it may be detected by adding gold leaf, which in that case will be dissolved.

16. *Nitric acid* may also be detected by protosulphate of iron, in the following manner :—To the acid under examination, add one-fourth of concentrated sulphuric acid, and the whole having become cold, drop into the liquid a crystal of protosulphate of iron ; if nitric acid be present, that portion of liquid immediately in contact with the crystal of the salt of iron will assume a brownish-black colour.

17. *Nitric acid* may also be detected in hydrochloric acid by scraping a quill-pen, pouring a few drops of the acid upon the scrapings, and boiling the whole ; the quill scrapings will then become yellow.

18. The presence of free *chlorine* in hydrochloric acid may be detected by adding thereto a few drops of solution of sulphate of indigo, which will then be decolorized. Free chlorine has besides a characteristic odour.

19. When hydrochloric acid contains sulphurous acid, the latter may be removed by adding a small quantity of peroxyde of manganese in very fine powder, and agitating the whole ; a certain quantity of chlorine is thus evolved, which transforms the sulphurous into sulphuric acid, thus :—



By careful distillation the hydrochloric acid passes over, leaving the sulphuric acid in the retort. If the small quantity of chlorine contained in the acid should prove objectionable, it may be removed by moderately heating the acid, or by putting aside the first portions which come over in distilling, as long as the solution of sulphate of indigo is decolorized.

20. The *perchloride of iron* may be eliminated by redistillation, it will remain in the retort.

21. If *arsenious* or *arsenic* acids be present, they may be removed by redistilling the acid with a small quantity of sulphuret of barium ; three or four thousandths of the latter substance are generally sufficient to convert the arsenious or arsenic acids into sulphuret of arsenic, which remains in the retort ; and this addition may be made immediately after that of the peroxyde of manganese, as above described.

22. *Arsenic* and *arsenious* acids may also be completely separated, by digesting the hydrochloric acid upon copper filings, decanting, and then distilling the acid.

HYDROCHLORATE OF AMMONIA.

See *Sal Ammoniac*.

HYPOCHLORITE OF LIME.—See *Chloride of Lime*.

INDIGO.

1. Indigo is a blue colouring matter, which can be extracted from several tropical plants, but nearly all the indigo of commerce is the product of the various species of *indigofera*. There are various modes of extracting indigo from the plant, and manufacturers differ in their opinion as to which is the best process of obtaining it.

2. Indigo should be in lumps of a fine deep purple colour, assuming a coppery hue when rubbed with a hard and polished body, such as the nail for example, and its fracture should be homogeneous, compact, fine-grained, and of a coppery colour. A dingy, dark, or brownish tinge is a sign

of adulteration or of bad quality. The lumps should be inodorous and light ; if heavy, earthy impurities are present.

3. Good indigo should leave only a fine streak when rubbed upon a piece of white paper, this being one of the tests of the best quality, called *fine blue*. The other qualities are known as *ordinary blue*, *fine purple*, *purple and violet*, *dull blue*, *inferior purple and violet*, *strong copper*, and *ordinary copper*.

4. Besides these various shades or differences in the colour, the value of indigo may also be deduced in various ways : thus, if indigo is too hard or brittle, the chests will contain a large proportion of small bits or powder ; if the lumps exhibit crevices, or if the outer surface is blackish, or greenish ; if, on breaking a lump, black spots are seen here and there ; or if it looks blistered, and has little cavities, generally white internally, which is probably due to mouldiness ; or if the lumps appear to consist of strata of various shades of colour, or be full of white spots, all these are imperfections or defects which affect the value of the drug in a serious manner. Indigo frequently contains sand, the presence of which may generally be detected by breaking a lump, and looking at the fracture whilst holding it horizontally between the eye and the light, in which case, small shining points may be observed, which are the particles of sand. In general, when indigo is in hard, dry lumps of a dark colour, it is considered of bad or of inferior quality. Indigo in dust, or in small bits, is often adulterated with sand, pulverized slate, and other earthy substances.

ESTIMATION OF THE VALUE OF INDIGO.

5. *The first step* is to determine the quantity of moisture contained in the sample. This is done by weighing off a certain quantity of the indigo under examination, (200 grains for example), and exposing it (in a steam-bath) to a tempera-

ture of 212° Fahr., until it no longer diminishes in weight, the loss should not be more than from three to six per cent.

6. *The second operation* is to determine the quantity of fixed inorganic matter; this is done by incinerating a given weight of the indigo, (20 grains for example,) in a small platinum crucible or capsule. During this process the indigo, if of good quality, fuses and emits fumes of a fine purple colour. The quantity of ashes left is in general from six to seven per cent., but the genuine indigo of Senegal leaves sometimes as much as twelve per cent. of ashes.

7. *The third operation* is performed as follows:—Introduce into a glass bottle, having a large mouth and provided with a glass stopper—

Indigo, dried at 212° Fahr.	10.0 grains.
Crystallized protosulphate of iron (free from copper)	36.0 „
Caustic potash	32.0 „
Water	10,000.0 „

8. The size of the bottle should be such that the above mixture will fill it completely, no air or empty space should be left, for otherwise the experiment may fail.

9. The above mixture should be well stirred, and after leaving it at rest for a quarter of an hour, the operator plunges into it 80 grains of spun-wool, leaving them immersed therein for about five or ten minutes, according to the depth of colour which he may wish to obtain.

10. The same process is repeated with indigo which is known to be of good quality or with indigotine, and the difference of colour indicates, of course comparatively, the value of the sample experimented upon.

11. This mode of estimating the value of indigo, however, shows only whether the drug is capable of producing a fine colour or not, but it does not indicate satisfactorily the quantity of available indigo which it contains, or in other

words, the extent of its tinctorial power. It is therefore better to leave the wool immersed into the liquor for about ten hours, and to replace it by a fresh quantity until the colouring matter is exhausted, the best indigo will, of course, dye the most stuff, and give the higher or deeper colour.

12. *M. Houtou Labillardière* determined the commercial value of indigo by means of an instrument to which he gave the name of colorimeter, and which consists of two perfectly cylindrical glass tubes, closed at one end of about half an inch bore, and about thirteen or fourteen inches long. These two tubes must be made of the same glass, and of the same diameter and thickness. At about the $\frac{5}{8}$ th part of their length from the closed end, they are divided into two parts of equal capacity, the second half being graduated into 100 divisions. These two tubes are then placed into a small wooden box through two contiguous openings at the upper part of the box, and immediately behind which tubes, two square holes or slits, corresponding to the diameter of the tubes, are cut, whilst the other end of the box, facing the tubes, has an eye-hole, so that by holding the box before the light, and looking at the tubes through the eye-hole, the difference of hue of the coloured liquor put into the tubes may be easily appreciated. The inside of the box should be blackened.

13. *Modus operandi.* Take a sample of each parcel of indigo to be examined, reduce the samples separately in fine powder, by trituration and sifting; weigh off 20 grains of each, and introduce that quantity (namely, 20 grains) into a small matrass perfectly clean and dry, pour upon it 400 grains of concentrated sulphuric acid of sp. gr. 1.845, and leave the whole exposed to a gentle heat of about 100 or 110° Fahr. for about one hour, shaking the matrass from time to time, in order to promote the solution. When the indigo has dissolved, and the liquor has become cold, the whole is emptied into a large glass bottle capable of holding four pints of liquor, stirring the whole well with a glass rod, the matrass should be well rinsed with water which is to be poured

into the bottle, and more water is added until the bottle is completely filled up. Take now 10,000 grains-measure of this liquor and pour them into another bottle, or glass beaker, which should be left at rest for a few hours so that the liquor may settle well. The rest of the liquor not being used may be thrown away.

14. If several samples of indigo have to be tested, the operation just described must be repeated on 20 grains of each, so that they may all be examined at the same time and in the same manner.

15. The solution having settled, a portion of it is poured into the colorimeter tubes up to 0°, they are then introduced into the holes in the box, and their tint is examined by looking at them through the eye-hole opposite ; if a difference in the depth of the colour is observed, water is added to that which has the deeper colour of the two ; the aperture of the tube being well closed with the finger, the liquid is well shaken and the tube is re-introduced back into its hole, water being again added, if need be, until the colour in the two tubes has acquired the same shade. By looking at the divisions on the tube to which water has been added, the operator knows at once the difference or relative colouring power of the two samples examined, for it is evident that that indigo is the richer or of more value which has required a greater quantity of water to be brought to the same pitch or intensity of colour as the other.

16. the value of indigo may also be tested in the following manner :—

17. Take a portion of the indigo to be examined, reduce it to powder and weigh off a certain quantity of it. Take also twice the weight of the indigo of quick lime obtained by calcining oyster shells or white marble ; and for each 20 grains of indigo weighed off, take 10,000 grains-measure of water ; with part of that water slake the lime, and with another portion of it grind the indigo into impalpable powder with a muller on a slab. The hydrate of lime (slaked lime) is then

mixed with the indigo, and the mixture is ground again with the muller as perfectly as possible. The triturated mass is then introduced into a large flask capable of holding the whole, taking care, of course, not to spill or waste anything, the slab and the muller are washed with some of the measured water which is also poured into the flask, and it is then filled up with the remainder of the water.

18. If the same flask is always used and its capacity is known, the operator may, of course, dispense with measuring the water.

19. The flask containing the mixture should be exposed for several hours at a temperature of from 176° to 194° Fahr. by keeping it plunged in a water-bath heated to that point. In consequence of this treatment the lime combines with the brown of indigo, and the colouring matter is set free. A little protosulphate of iron (free from copper), finely pulverized, must be dissolved in the liquor. The quantity of protosulphate of iron should be about two-thirds of the lime employed. As soon as this is done, the flask must be closed and well stirred, and it is again placed in the water bath, and allowed gradually to cool there. The mixture gradually becomes green; when it has cooled, the clear liquor should be siphoned out from the sediment into a graduated vessel, up to a certain point. The colouring matter becomes oxydized by the air, and in order to promote this oxydization, and to keep the lime and other foreign bodies in solution, a little hydrochloric acid should be added to the decanted liquor. When it has cleared it is poured on a weighed filter, and the precipitate thus separated, and which is pure indigo, being washed and dried at 212° Fahr. is then weighed.

20. Suppose, for example, that the quantity of indigo operated upon is 100 grains, which will have required 500 divisions (50,000 grains-measure) of water, and that 200 divisions (20,000 grains-measure) having ultimately been left to oxydize, have yielded 15 grains of indigo, the indigo under examination contained $37\frac{1}{2}$ per cent. of pure indigo.

$$200 : 15 :: 500 : x = 37.5.$$

21. M. Dana proposed another method (*Journal for Prac. Chem.* XXVI. p. 398), which consists in boiling the indigo with carbonate of soda, adding protochloride of tin from time to time, and precipitating the clear solution by one of bichromate of potash, filtering, washing the precipitate with dilute hydrochloric acid, in order to remove the hydrate of oxyde of chromium, drying, and then weighing the indigo which should then be incinerated, and the ashes being deducted from the weight thus obtained, gives the proportion of pure indigo.

22. *Fritsche's process.* If indigo be treated with a solution of caustic potash in spirits of wine, a small quantity of peculiar indigo blue is obtained in the form of scales. The process is based on the reduction of indigo, for which purpose spirit of wine is used instead of water, as in the ordinary process; and in lieu of the substances employed in other cases for effecting this reduction, grape sugar is substituted on account of its solubility in alcohol; for the same reason lime is replaced by caustic potash, or caustic soda.

23. One part of indigo, with one part of grape sugar, are put into a bottle capable of containing 40 parts of liquor. The bottle is half filled with boiling alcohol, and the other half with alcohol previously mixed with $1\frac{1}{2}$ parts of very concentrated ley of caustic soda. The bottle being thus charged is strongly agitated, and then left at rest for some time. After the liquid has become bright, it is drawn into another bottle by means of a siphon. The liquor thus obtained, whilst protected from the contact of the air, is of a yellowish-red colour, and so dark that it appears transparent only when in thin layers. As soon, however, as it is exposed to the influence of the oxygen of the air it becomes purple, and quickly passes through the different tinges of red, violet, and blue, whilst the whole of the indigo blue is deposited in the form of scales. This is obtained as a very fine, light,

crystalline powder ; whilst all the other substances contained in commercial indigo, either remain undissolved at the commencement, or remain in solution whilst the blue colouring matter is depositing. After the indigo blue has been placed on a filter and washed with a little alcohol, it must be washed with water, and this is easily and speedily effected. On the crystals, minute globules of a substance insoluble in alcohol are commonly deposited, which, however, easily dissolve in water, and are produced by the action of caustic soda on the grape sugar.

24. Commercial indigo seldom contains 50 per cent. of blue colouring matter, the remainder consist of either accidental or of intentional impurities. In general it may be said, that the lighter the specific gravity of the lumps of indigo, the better the drug.

IODIDE OF POTASSIUM.

HYDRIODATE OF POTASH.

1. Iodide of potassium, until lately, was employed for medicinal purposes only ; it is now extensively used in photography.

2. Iodide of potassium is white and opaque ; it has a pungent taste, and it emits purple fumes when treated, with the help of heat, by either nitric or by sulphuric acid ; it crystallizes in cubes ; 100 parts of water at 64° Fahr. dissolve 143 parts of iodide of potassium.

3. Commercial iodide of potassium is sometimes contaminated by *chloride of potassium* or other *chlorides* ; occasionally it contains also some *potash*, or *carbonate of potash*, and likewise *iodate of potash*, especially when manufactured on a large scale.

4. Pure iodide of potassium should entirely dissolve in water and in alcohol ; it should have no action, or only in a

very trifling degree, upon litmus or turmeric paper, or else it is a sign that a free acid or alkali is present; it should not lose weight by ignition, if it does the loss is probably water.

5. The presence of *chloride of potassium* is recognized by precipitating the solution of iodide of potassium under examination by a slight excess of nitrate of palladium which produces a precipitate of iodide of palladium, which may be separated by filtering; the filtrate is then treated by solution of nitrate of silver which will produce a white, curdy precipitate of chloride of silver, if chloride of potassium or any chloride is present. The chloride of silver so produced may be collected on a filter, washed, dried, fused in a porcelain crucible, and then weighed. 144 grains of chloride of silver represent 76 of chloride of potassium, or 1 equivalent of any other chloride; or the quantity of chloride of silver produced may be determined by measure. (See the article on *Silver*.)

6. The presence of *chloride of potassium* may also be detected by distilling the iodide of potassium under examination with sulphuric acid, previously mixed with a little bichromate of potash, and leading the products of the distillation into a solution of potash, which remains colourless if the iodide of potassium is pure, but which becomes yellow if it contains any chloride of potassium.

7. *Chloride of potassium* may likewise be detected in the iodide under examination by precipitating its solution by an excess of an ammoniacal solution of nitrate of silver, in which case the iodide of silver alone is precipitated. The liquor, filtered from this precipitate, is then supersaturated with nitric acid, which will produce a precipitate of chloride of silver, from the weight of which the quantity of chloride of potassium in the iodide may be calculated, as above said.

8. Iodide of potassium has been known to contain as much as 50 per cent. of salt.

7. If, instead of an ammoniacal solution of nitrate of silver, a simple aqueous solution of this nitrate were used, both the iodide and the chloride would be precipitated, but by digesting the precipitate in caustic ammonia the chloride of silver is redissolved. The ammoniacal solution being then filtered from the iodide, and supersaturated with nitric acid, the chloride of silver will be reprecipitated, from which the quantity of the chloride of potassium present in the article under examination may be estimated.

8. If both a *carbonate* and a *chloride* are present at the same time, the carbonate should be first separated, as will be shown presently ; or else, if the solution of nitrate of silver be added at once to that of the iodide of potassium containing a carbonate, and a chloride, the whole would be precipitated as iodide, chloride, and carbonate of silver ; but, upon treating the precipitate with ammonia, the carbonate and the chloride of silver will be redissolved, but not so the iodide of silver, which may then be separated by filtering, as we said, and upon adding nitric acid to the ammoniacal filtrate, the chloride of silver is reprecipitated, whilst the carbonate of silver, being converted by the acid into nitrate of silver, remains in solution.

9. To resume. If, after having poured an excess of ammonia in the liquor containing the precipitate of iodide of silver, produced by a solution of nitrate of silver, the further addition of dilute nitric acid to the ammoniacal liquor filtered from the precipitate of iodide of silver, produces an abundant precipitate in the filtered liquid, it is a proof that the solution of the metallic iodide contained at the same time a chloride ; if, on the contrary, a very feeble precipitate is produced, or rather, if the liquor only becomes slightly opaline, one may conclude that the liquor either contained no chloride, or at any rate a trace only.

10. The presence of *potash* in the free state may be recognized in the solution of the iodide of potassium, by adding

a small quantity of iodine, which dissolves without colouring the solution if potash is present, but, in the contrary case, the solution turns brown. Care must be taken, however, to add only a very small quantity of iodine, for pure iodide of potassium, in dissolving the iodine, turns brown.

11. *Carbonate of potash* is detected by mixing the iodide of potassium under examination with milk of lime, filtering the liquor, and adding to the filtrate a very small quantity of iodine, which will dissolve without colouring the liquor. MM. Christison and Pereira found that substance adulterated with as much as from 74 to 77 per cent. of carbonate of potash.

12. The quantity of *caustic* or of *carbonated alkali* may be approximatively estimated, by means of test-sulphuric acid of a known strength, adding it until the liquor becomes neutral, (see *Alkalimetry*.) The addition of the acid in the latter case disengages carbonic acid.

13. A ready method of estimating the quantity of *carbonate of potash* consists in treating the suspected sample with alcohol, which will dissolve the iodide of potassium, and leave the carbonate of potash in an insoluble state.

14. If iodide of potassium contains any *sulphate*, the addition of a solution of chloride of barium to that of the iodide, will produce a precipitate of sulphate of baryta, insoluble in acids and in water. This precipitate may be washed, dried, and ignited. 117 grains of sulphate of baryta represent one equivalent of any sulphate.

15. The presence of *iodate of potash*, which sometimes contaminates iodide of potassium, from a faulty preparation, is easily detected by adding to its aqueous solution one of tartaric acid, which, if the salt be pure, will in a short time produce a yellow colour, and a crystalline precipitate of bitartrate of potash; but if the salt contains any iodate of potash, free iodine will be disengaged, and its presence may then be recognized by solution of starch. A crystalline precipitate of bitartrate of potash is produced in either case.

I O D I N E.

1. Iodine is a simple body, solid at the ordinary temperature, of a bluish-black colour and metallic lustre, like black lead ; it is often met with in flakes or in plates. It is soft and friable to the touch, its taste is very acid, and its odour resembles that of chlorine. When touched, it leaves a brown stain on the skin, but the stain disappears by evaporation. Its structure is lamellated ; its specific gravity is 4.946.

2. Iodine is sometimes adulterated with *graphite* (black-lead, plumbago), *peroxyde of manganese*, *crude antimony*, *micacious iron ore*, with *coals*, &c. As, however, iodine is entirely soluble in alcohol, these sophistications are very easily detected. Iodine, besides being entirely volatilizable by heat in fine purple fumes, readily condensable, it may be thus easily separated by sublimation, at about 356° Fahr., and directly weighed, separately from the fraudulent additions.

3. If dissolved in alcohol, the iodine may be readily recovered, simply by pouring into the alcoholic solution, a sufficient quantity of water, which precipitates it in the form of a brown powder, which may be collected on a filter, carefully dried, and weighed.

4. The iodine met with in commerce is always adulterated by variable proportions of water, sometimes to the extent of 15 or 18 per cent. This impurity may be detected by pressing it gently between folds of blotting paper, and then putting it under a glass bell, in a shallow basin or capsule, by the side of or above a dish containing caustic lime or concentrated sulphuric acid, by which the moisture is absorbed. When the weight diminishes no longer, the loss indicates the amount of water.

IRON.

ANALYSIS OF IRON ORES.

1. Iron ore is the name given to any substance containing enough iron to repay the expense of extracting it, and as even small proportions of phosphorus, of sulphur, or of arsenic, are exceedingly prejudicial to the quality of iron, the toughness of which they either impair or destroy, the ores containing any of these substances are rejected.

2. The ores of iron most generally employed are the *magnetic oxyde of iron*, *anhydrous peroxyde of iron* (fer oligiste), *hydrate of peroxyde of iron* (hematite), *carbonate of protoxyde of iron* (black band), *argillaceous carbonate of iron* (clay iron stone); all these ores are converted by roasting into sesquioxycde of iron.

3. Iron ores are ordinarily assayed, in the dry way, as follows :—

4. Take a Hessian crucible previously soaked in water, fill it with lamp black, rammed tightly into it, and then scoop out the lamp black from the middle, so as to form a cavity, having the form of the crucible, which will thus be lined with lamp black. This is called a *brasque*, and is in fact a crucible of charcoal within an ordinary crucible. The cavity formed, as above said, should be polished with a glass rod, and the crucible should be carefully and slowly dried.

5. Into the cavity of the *brasque*, introduce 150 or 200 grains of the ore, reduced into very fine powder, and mixed with half or two thirds of its weight of borax, or of glass, well pulverized, and keep the whole for two hours, at the temperature of a good air-furnace, or in a smith's forge. The crucible is then allowed to cool, and the cast iron at the bottom is removed from the crucible and weighed. The dif-

ference of weight between the iron obtained and the ore employed, gives, of course, that of the gangue or slag.

6. We just said that borax or glass might be used to assay iron ores, but the proportions of this solvent should be varied, according to the mixtures of the iron stones or ores. The flux generally employed in iron assays consists of bottle glass, chalk, and charcoal, mixed in various proportions in a Hessian crucible, with the ore to be assayed.

7. The simple combinations of the earths, and their degree of predominancy, have been thus arranged by Mr. D. Mushet :—

		1st variety.	2nd variety.
I.	Argilaceous Iron Stone.	{ Iron.	Iron.
		{ Clay.	Clay.
		{ Lime.	Silex.
		{ Silex.	Lime.
II.	Calcareous Iron Stone.	{ Iron.	Iron.
		{ Lime.	Lime.
		{ Clay.	Silex.
		{ Silex.	Clay.
III.	Siliceous Iron Stone.	{ Iron.	Iron.
		{ Silex.	Silex.
		{ Lime.	Clay.
		{ Clay.	Lime.

8. The proportions of flux employed by Mr. Mushet for the assay of these various ores, are as follows :—

9. I. 1st variety of argilaceous iron stone, supposed to consist of clay 9, lime 6, sand 3 = 18.

To assay	4	ounces troy of such ore	=	1920	grains.
Add	.	4	do. bottle glass	.	= 1920 "
"	.	3	do. chalk	.	= 1440 "
"	.	$\frac{1}{2}$	do. charcoal	.	= 240 "
				<u>5520</u>	

10. 2nd variety of argillaceous iron stone supposed to contain clay 10, silex 7, lime 3 = 20.

To assay	4	ounces troy of such ore	=	1920	grains.
Add	.	4	do. bottle glass	.	= 1920 „
„	.	4	do. chalk	.	= 1920 „
„	.	$\frac{3}{4}$	do. charcoal	.	= 360 „
					6120

11. Most common clay iron stones, however, may be perfectly reduced with the same additions of lime as made in the blast-furnace, that is, from equal weight to double the weight of the ore. If upon first fusion of an ore, the glass is dark and concave on the surface, the reduction is imperfect, add therefore charcoal and lime.

12. II. Calcareous iron stone, 1st variety, supposed to contain lime 14, clay 6, silex 4 = 24.

To assay 4	ounces troy of such ore	=	1920 grains.
Add . 5	do. bottle glass .	=	2400 „
„ . 1½	do. chalk . .	=	720 „
„ . ¾	do. charcoal .	=	360 „
			6120

13. 2nd variety of calcareous iron stone, supposed to contain lime 10, sand 6, clay 4 = 20.

To assay	4	ounces troy of such ore	=	1920	grains.
Add	.	4	do. bottle glass	.	= 1920 „
„	.	2	do. chalk	.	= 960 „
„	.	0½	do. charcoal	.	= 240 „
					5040

14. III. Siliceous iron stone, 1st variety, supposed to contain silex 12, clay 8, lime 5 = 25.

To assay	4	ounces troy of such ore	=	1920	grains.
Add	. 4	do. chalk	.	=	1920 "
"	. 3	do. bottle glass	.	=	1440 "
"	. $\frac{3}{4}$	do. charcoal	.	=	360 "
				5640	

15. 2nd variety of siliceous iron stone, supposed to contain silex 10, lime 7, clay 5 = 22.

To assay	4	ounces troy of such ore	=	1920	grains.
Add	. 3½	do. chalk . .	=	1680	„
„	. 3	do. bottle glass .	=	1440	„
„	. ¾	do. charcoal .	=	360	„
				5400	

16. Equalized mixture composed of clay 7, lime 7, silex 7 = 21.

To assay	4	ounces troy of such ore	=	1920	grains.
Add	. 3½	do. bottle glass .	=	1680	„
„	. 2½	do. chalk . .	=	1200	„
„	. ½	do. charcoal .	=	240	„
				5040	

17. Hematites, which are hydrated peroxydes of iron, and of which there are several varieties, consist of peroxyde of iron, with from 2 to 9 per cent. of silica, and may be assayed by taking—

4	ounces troy of hematite .	=	1920	grains.
1½	do. dried chalk . .	=	720	„
¾	do. charcoal . .	=	360	„
				2000

18. Kidney iron ore may be accurately assayed by taking—

4	ounces troy of kidney ore .	=	1920	grains.
1¼	do. chalk . . .	=	600	„
¼	do. glass . . .	=	120	„
¼	do. charcoal . . .	=	120	„
				2760

19. The object of an assay by fusion, as just described, is not only to determine the richness of the ore, and the quality of the iron which it may give, but an experienced person will also be able to know from the appearance of the slag, the nature of the gangue or matrix of the ore, and according as the slag will be compact, or porous, vitreous, stony, transparent, semi-transparent, opaque, or streaky, he will be guided as to the treatment of the ore in the smelting furnace. It is therefore important to examine the nature of the slag produced, as well as the quality of the iron obtained. Good cast iron flattens a little under the hammer before breaking ; bad cast iron is brittle, white, shining, bright, full of holes, and has a crystalline appearance.

20. In the treatment of iron ores in smelting furnaces, the ore must, of course, be completely fused, in order that the iron contained in the ore may unite with the carbon of the coke to produce cast iron, whilst the earthy matter of the gangue runs off in the state of scories.

21. In order, however, to determine the perfect fusion of this earthy matter, a flux must be employed, which for argillaceous ores is carbonate of lime (chalk), by which means the silica and alumina, or clay, are converted into a fusible silicate of alumina and of lime. But if the ore be of a calcareous nature, it is clear that instead of carbonate of lime a siliceous substance must be used as flux, or at any rate that the proportion of chalk must be reduced in order to produce a fusible silicate of lime. It is therefore necessary sometimes to analyze the ore, in order to determine not only what kind of flux must be employed, but likewise what quantity of such flux will be required to fuse the ore. This being ascertained, the operator mixes it with the ore, and after fusion the quality and quantity of iron, of cast iron, which the ore may yield, is ascertained as described before.

22. Take 300 or 400 grains of the ore, and calcine, or roast it until it ceases to lose weight ; the loss will indicate the quantity of water, of carbonic acid, or of combustible matter

contained in the ore. Take now 150 or 200 grains of the roasted ore, previously reduced into very fine powder, and boil it with 1500 or 2000 grains-measure of hydrochloric acid. If the ore is an argillaceous iron ore (clay iron-stone), no effervescence will take place. The insoluble residuum should be well washed, ignited, and weighed. This weight indicates the quantity of silica and of clay contained in the ore.

23. When the ore is calcareous, or when it is a magnesian iron stone, the lime or the magnesia is determined by treatment with acetic acid, or with very dilute nitric acid, by which the earthy carbonates are dissolved, but which has no action upon the clay, silica or oxyde of iron. The residuum is washed, dried, and weighed; the loss indicates the proportion of the carbonates contained in the ore, which have been dissolved, as just said.

24. It is known, by experience, that for clay iron-stone, a quantity of carbonate of lime (chalk) is required for flux, equal to at least one-half or two-thirds more than the weight of the clay, and when, after treatment of the ore with hydrochloric acid, the residuum contains more silica than usual, magnesian lime-stone (Dolomite) should be used instead of chalk.

25. It is always advisable, however, to maintain the lime in excess, because it displaces the protoxyde of iron which has always a tendency to unite with the slag, to form a fusible silicate of iron, which cannot be reduced by any quantity of fuel.

26. A good slag has the following composition :—

Silica	.	.	.	.	50
Lime	.	.	.	.	30
Alumina	.	.	.	.	18

—
98 from grey cast iron.
—

27. For white cast iron the proportion of lime is augmented a little.

28. The following analyses of slags are given by Berthier :—

Silica	35.4	46.6
Lime	38.4	28.3
Magnesia	1.5	0.6
Alumina	16.2	18.8
Protoxyde of iron	1.2	1.8
Protoxyde of Manganese	2.6	2.6
Sulphur	1.4	1.2
	96.7	99.3

29. Another method of determining, in the dry way, the quantity of iron contained in iron ores, consists, according to Liebig, in first reducing the ore into fine powder, adding thereto a mixture of cyanide of potassium and of carbonate of potash, and exposing the whole to a strong heat in a porcelain crucible. The alumina and silica remain in the scories, from which the reduced iron may be separated by washing with cold water, and it is then dried and weighed.

30. The analysis of iron ore in the wet way is more accurate than in the dry way, and may be performed in the following manner :—

Analysis of clay iron-stone in the wet way.

31. If the object in view be merely to determine the quantity of iron contained in the ore, it (the ore) should first be reduced into fine powder, and about 50 grains of it should be dissolved in aqua regia, with the help of heat, and filtered in order to separate the silica, and also a little alumina which sometimes is left in an insoluble state ; an excess of ammonia is then added to the filtered liquor, which produces a reddish-brown precipitate of peroxyde of iron mixed with alumina, which is collected on a filter, washed, and then boiled with a solution of caustic potash, in order to dissolve the alumina. The whole is then thrown upon a filter, the peroxyde of iron

remains on the filter, on which it is washed ; it is then dried, carefully ignited, and weighed. 80 grains of peroxyde of iron represent 56 of metallic iron, or each grain of peroxyde of iron contains 0.69338 grain of metallic iron.

32. But in order to determine the proportion of the other constituents of the ore, proceed as follows :—

33. Reduce into very fine powder a certain quantity of the ore, and dissolve a given weight of it in aqua regia with the aid of heat, as was said before ; this will produce a disengagement of carbonic acid from the carbonates contained in the ore, and will leave an insoluble residuum of silica, mixed with a little alumina, which insoluble residuum should be separated by filtering, and the liquor filtered therefrom must be evaporated to dryness. The dry residuum should then be treated by dilute hydrochloric acid, the silica remains in an insoluble state, and may then be separated by filtering. An excess of ammonia is then added, yet, if magnesia is one of the constituents of the ore, which is generally the case with clay iron ore, the operator, before adding the excess of ammonia to the filtrate, as just said, should first pour into it a pretty large quantity of a solution of sal ammoniac, in order to prevent the magnesia from being precipitated by the excess of ammonia which is subsequently added. If, however, the solution is very acid, this addition of sal ammoniac is not necessary. The excess of ammonia employed, as just said, will produce a reddish-brown precipitate, which consists of peroxyde of iron mixed with alumina, which after being collected on a filter, should be redissolved in a little hydrochloric acid, and then reprecipitated by an excess of solution of caustic potash ; on boiling the whole, the alumina, which will have been at first precipitated along with the peroxyde of iron by the solution of caustic potash, will be redissolved by that reagent, whilst the peroxyde of iron is left in an insoluble state. The operator, however, must make sure that he has used a sufficient quantity of potash to dissolve all the alumina which is mixed with the peroxyde

of iron ; this is ascertained by letting a drop of hydrochloric acid fall into the liquor filtered from the peroxyde of iron. If this produces a cloud which disappears on stirring, it is a proof that the potash is in excess, and it is all right ; but if, on the contrary, the cloud produced by the drop of hydrochloric acid does not disappear on stirring, the peroxyde of iron should be boiled with more potash.

34. The liquor filtered from the peroxyde of iron, and which contains the alumina in solution, must now be supersaturated with hydrochloric acid, and the alumina is precipitated therefrom by a solution of carbonate of ammonia ; the precipitated alumina is then collected on a filter, washed with boiling water, thoroughly dried, ignited, and then weighed.

35. Where great accuracy is required, the peroxyde of iron which was left in an insoluble state, after boiling with caustic potash, should be redissolved in hydrochloric acid, and then neutralized by ammonia until a few reddish-brown flakes begin to appear, and the precipitation of the peroxyde of iron is completed by means of a solution of *neutral* succinate of ammonia ; the precipitated persuccinate of iron is then collected on a filter, washed, dried, ignited, and weighed as peroxyde of iron.

36. The liquor filtered from the persuccinate of iron is then mixed with that which was filtered from the precipitate of peroxyde of iron mixed with alumina, produced in the first instance by the excess of ammonia, and solution of oxalate of ammonia is then added, which will precipitate the lime in the state of oxalate of lime ; the liquor should be left at rest, and in a warm place for several hours, in order that the precipitate may settle completely ; it is then collected on a filter, washed, dried, ignited, and weighed in the state of carbonate of lime, as described, page 146, § 14.

37. If the ore contains any manganese, the liquor filtered from the oxalate of lime should be treated by hydrosulphuret of ammonia, which will produce a flesh-red precipitate of

sulphuret of manganese. This precipitate is allowed to settle completely, it is then collected on a filter, and washed, without interruption, with water containing a little hydrosulphuret of ammonia. The washed precipitate is then introduced with the moist filter into a glass-beaker, and treated therein with hydrochloric acid, with the help of a gentle heat, until all odour of sulphuretted hydrogen has disappeared. The liquor is then filtered, carbonate of soda is added, and the whole is boiled for some time. The precipitate thus produced is collected on a filter, washed, dried, exposed to a strong bright red heat, and finally weighed. During the ignition, the precipitate is converted into red oxyde of manganese, each grain of which contains 0.72093 grain of manganese.

38. The liquor which was filtered from the sulphuret of manganese, produced by hydrosulphuret of ammonia, and which contains all the magnesia, should be rendered slightly acid by means of hydrochloric acid, in order to destroy the excess of hydrosulphuret of ammonia employed, and it is boiled until the odour of sulphuretted hydrogen has disappeared; it is then filtered, evaporated to dryness, in order to volatilize the ammoniacal salts, sulphuric acid slightly diluted is carefully poured upon the ignited mass, and the whole is evaporated to dryness, slightly ignited in order to eliminate the excess of sulphuric acid, and the residuum, which is neutral sulphate of magnesia, is weighed. 60 grains of sulphate of magnesia contain 20 of magnesia, or each grain of sulphate of magnesia contains 0.34015 grain of magnesia.

Analysis of iron ores by Margueritte's process.

39. This process, which is often used for the estimation of nitrate of potash, is applicable also to the analysis of iron ores, of the alloys of this metal, and of the mixtures of protoxyde and of peroxyde of iron, which are found in *clay iron-stone*, and in *Mushet's ore*, or *black band*. The

process is based upon the mutual reaction of the proto-salts of iron upon permanganate of potash. When a solution of permanganate of potash is poured in a very dilute acid solution of a protosalt of iron, the protosalt of iron becomes peroxydized at the expense of the oxygen of the permanganate, the solution of which becomes decolourized. As long as any protosalt of iron remains, it is immediately decomposed as rapidly as the solution of the permanganate is gradually poured into it, the liquor assuming a very pale yellow colour, due to the peroxyde of iron produced ; but as soon as all the iron is peroxydized, one single drop of permanganate suffices to impart a distinct pink colour to the liquor, which colour indicates that the experiment is finished. We have described in the article on *Nitrate of Potash*, the manner of preparing the test-liquor of permanganate of potash, and supposing that the said test-liquor is such that each division of the alkali-meter represents 0.5 grain of metallic iron, the analysis is performed as follows :—

40. Take 20 grains of the iron ore and reduce them into very fine powder by levigation ; put them into a flask capable of holding about a quart of water, and pour into it about 1000 grains-measure of pure and fuming hydrochloric acid. The mixture is moderately boiled until the ore has dissolved. Common water is then poured in so as to fill up about one-third of the flask, and the salt of iron is brought altogether to the state of protosalt by adding about 100 grains of pure zinc, free from iron, or about 60 grains of sulphate of soda. After boiling for a few minutes, and as soon as the liquor no longer evolves an odour of sulphurous acid, and has become greenish or almost colourless, all the iron has passed into the state of protosalt. The solution is then diluted with a fresh quantity of water, so as almost to fill the flask, and the test-liquor of permanganate of potash is then poured in, drop by drop, until the characteristic pink colour is produced. The operator then reads off the number of divisions employed.

41. Let us suppose, for example, that the test-liquor is of

such a strength that each division represents 0.5 grain of pure iron, and that 22 divisions have been required to peroxydize the iron contained in the 20 grains of ore operated upon; it is evident that these 20 grains contained 11 grains of iron, and, consequently, 55 per cent. of iron.

$$20 : 11 :: 100 : x = 55.$$

42. This process is evidently much more rapid than those which were described before, and the presence of zinc, of manganese, of phosphoric acid, of lime, of alumina, magnesia, and silica, does not interfere with its accuracy. But if the ore contains arsenic, or copper, these substances should be separated from the acid solution by a bar of zinc, because they would become peroxydized at the expense of the permanganate of potash. These substances should therefore be collected on a small filter, carefully washed, and the water used for washing being mixed with the filtrate, the whole is treated as we just said. But if the ore contains both protoxyde and peroxyde of iron, and the operator wishes to determine the proportion of these two oxydes, proceed as follows :—

43. Take 20 grains of the ore containing the two oxydes, reduced into very fine powder, as before mentioned, and dissolve them into about 1000 grains-measure of fuming hydrochloric acid; dilute the solution with water, so that it may form about one quart of liquid, and gradually pour into it, drop by drop, the test-liquor of permanganate of potash until the liquor assumes a pink colour.

44. Let us suppose that the test-liquor being of the same strength as before, the 20 grains of ore have required 12 divisions of the permanganate of potash test-liquor; the quantity of iron contained in the state of protoxyde is 6 grains, and, consequently, the ore contains 30 per cent. of metallic iron in the state of protoxyde.

$$20 : 6 :: 100 : x = 30,$$

and as 28 grains of iron represent 36 grains of protoxyde, the 30 grains of iron indicated in the experiment represent therefore 38.57 grains of protoxyde of iron.

45. The proportion of iron contained in the ore in the state of peroxyde, is ascertained by dissolving another 20 grs. of the same ore in 1000 grains of fuming hydrochloric acid, as before; the iron is then converted into a protosalt by means of pure zinc, or of sulphate of alkali, as mentioned in the first experiment, and the whole quantity of the iron is determined as usual.

46. Let us suppose that this second experiment indicated 55 per cent. of iron, the operator subtracts 20 per cent. of iron found by the preceding experiment as being in the state of protoxyde, which gives 25 per cent. as the quantity of metallic iron in the state of peroxyde; the ore contains therefore—

30 of metallic iron	=	38.57	protoxyde of iron.
25 of ditto	=	35.71	peroxyde of iron.
		25.72	foreign substances.

100.00

47. *Hematite* is an ore of iron which consists of *peroxyde of iron, silica, lime, and water*; it may be analyzed in the wet way as follows:—

48. A portion of the ore is to be first reduced into very fine powder, treated by hydrochloric acid with the help of heat, and then evaporated to dryness. The dry mass is to be moistened with hydrochloric acid, and water is added. The whole is thrown on a filter in order to separate the silica. The filtrate is next treated by an excess of ammonia, which precipitates the peroxyde of iron, which may then be collected on a filter, washed, dried, ignited, and weighed.

49. To the liquor filtered from the peroxyde of iron precipitated by ammonia, oxalate of ammonia is added, which produces a precipitate of oxalate of lime, which is allowed to settle well, after which it is collected on a filter, washed, dried, and ignited, in order to convert it into carbonate of lime, in which state it is weighed. 50 grains of carbonate of lime contain 28 of lime, or each grain of carbonate of lime contains 0.56292 grain of lime. The analysis of a sample of hematite by this method, yielded peroxyde of iron 94.5, silica 2.9, lime 1.3, water 1.3.

50. *Spathose iron* is a combination of carbonic acid with protoxyde of iron, of which a portion is sometimes replaced by protoxyde of manganese, lime, and magnesia. The analysis of this ore may be performed in the following manner :—

51. Dissolve the finely pulverized ore in nitric acid, and filter in order to separate the silica. To the filtrate add solution of sal ammoniac, and then an excess of ammonia, which precipitates the iron in the state of peroxyde of iron, the magnesia being kept in solution by the sal ammoniac previously added. Collect the precipitated peroxyde of iron on a filter, wash, dry, ignite, and weigh.

52. To the liquor filtered from the peroxyde of iron, add oxalate of ammonia; a white precipitate of oxalate of lime falls down, which is collected on a filter, washed, dried, and ignited, as described before.

53. If the ore contains manganese, it should be precipitated in the state of sulphuret, as described at the beginning, page 117, § 37. The presence of manganese in the ore may be detected by mixing a portion of it, pulverized, with carbonate of soda, and heating it before the blowpipe on a strip of platinum. The melted mass will assume a green colour, if manganese is present.

54. Lastly; by adding phosphate of soda and ammonia to the filtrate, as described before, a precipitate of ammonio-phosphate of magnesia will be produced, either immediately, or after a while.

55. This ore, analyzed by Beudant, Berthier, and Klaproth, gave the following results :—

	England.	Baigony.	Hartz.
Protoxyde of iron .	59.97	53.0	57.50
Carbonic acid .	38.72	41.0	36.00
Oxyde of Manganese	0.39	0.6	3.30
Lime . . .	0.92	0.0	1.25
Magnesia . . .	0.00	5.4	0.00
	100.00 Berthier.	100.0 Berthier.	100.00 Klaproth.

56. *Analysis of cast iron.* Cast iron is a combination of metallic iron and carbon, which takes place in the smelting furnace, and of which there are three varieties ; the white, the grey or mottled, and the black. Although cast iron is essentially a carburet of iron, yet its constituents do not consist of iron and carbon only, but it generally contains besides several foreign substances, such as *silicium*, *manganese*, *phosphorus*, &c., the presence of which modify the properties of cast iron very materially.

57. The following table shows the composition of cast iron :—

Constituents.	South Wales with Coke. By Gay Lussac.			Franche Comté with Coke.	Creuzot with Coke.	Cham- pagne with Wood.	Nivernais with Wood.
Carbon	2.450	2.550	1.666	2.800	2.021	2.100	2.254
Silicium	1.620	1.200	3.000	1.160	3.490	1.060	1.030
Phosphorus ...	0.780	0.440	0.492	0.351	0.664	0.869	0.043
Manganese ...	Trace	Trace	Trace	Trace	Trace	Trace	Trace
Iron	95.150	95.810	94.842	95.689	93.835	95.971	95.673
	100.000	100.000	100.000	100.000	100.000	100.000	100.000

58. Some varieties of cast iron may contain as much as 5 per cent. of carbon.

59. Mr. L. Swanberg gives the following analysis of cast iron from North America :—

GREY CAST IRON.

	Juniata.	Longmine, Orange, County of New York.	Salisbury, Connec- ticut.	Iron Mountain, Missouri.	Anthracite Smelting furnace Columba, Donville.
Carbon.....	2.8913	2.3909	3.0529	5.8617	6.4797
Silicium.....	0.8293	1.9042	1.3442	1.0948	1.9607
Phosphorus.....	0.1592	0.0972	0.1224	0.1806	1.4591
Sulphur.....	0.0052	0.0044	0.0028	0.0170	0.0020
Copper.....	Trace	—	0.0101	0.0235	—
Iron.....	96.1150	95.6033	95.4676	92.8224	90.0985
	100.0000	100.0000	100.0000	100.0000	100.0000

60. Cast iron from the smelting furnace of the Lehigh Iron Company, contained—

Carbon	.	.	.	4.4064
Silicium	.	.	.	1.0350
Sulphur	.	.	.	0.0900
Calcium	.	.	.	0.0163
Aluminium	.	.	.	0.0406
Copper	.	.	.	0.0152
Phosphorus	.	.	.	0.0017
Iron	.	.	.	94.3948
				100.0000

61. *White cast iron* is produced in the smelting furnace when mangesiferous ores are employed, or when the quantity of ore smelted is proportionally greater than that of the coke ; *white cast iron* is produced also when grey cast iron is suddenly chilled. It has a metallic lustre, and sometimes a silvery appearance. When it contains manganese, it often crystallizes in voluminous quadrangular pyramids. Its sp. gr. is from 7.44 to 7.84.

62. When *white cast iron* is treated by an acid, no graphite is deposited, as is the case with grey cast iron. Mangesiferous white cast iron is generally employed for the manufacture of steel.

63. *Grey cast iron* is generally produced from ores of

a good quality when the smelting is properly managed. Its colour is grey, its fracture is granular, always porous, and never takes a good polish. Its sp. gr. varies from 6.79 to 7.05. It may be easily filed or bored, and if treated by acids, a residuum of graphite is left, though in less considerable quantity, however, than is the case with black cast iron, and it always contains a certain quantity of silicium, as shown in the preceding tables.

64. When *grey cast iron*, being fused, is suddenly chilled by throwing cold water upon it, it undergoes a species of temper, and becomes converted into white cast-iron, which modification is always produced, as least partially, even when it is cooled too rapidly; and in that case it becomes harder, more brittle, and the carbon, instead of being as before, merely in the state of solution in the iron, enters then probably into a state of combination with the iron; for after having been thus chilled, it no longer deposits graphite by treatment with an acid, the carbon escaping in the state of carburetted hydrogen.

65. The presence of phosphorus in grey cast iron diminishes its tenacity, but augments its fluidity, and renders it more applicable to the casting of objects of art.

66. *Black cast iron* owes its colour and properties to a certain quantity of carbon which has dissolved whilst treating the ore with an excess of coke in the smelting furnace. Black cast iron is slightly malleable, but is easily fractured. It is more fusible than either white or grey cast iron, and when treated by acids, the hydrogen disengaged is always mixed with carburetted hydrogen, which gives the gas a fetid odour, and an abundant residuum of graphite is left.

67. The presence of iron, carbon, silicium, aluminium, manganese, phosphorus, and sulphur contained in cast iron, may be detected, and the respective quantity of these substances determined in the following manner :—

68. Dissolve a given weight of the cast iron under examination in aqua regia, evaporate the solution to dryness, mix the residuum with three or four times its weight of car-

bonate of soda, and fuse it in a platinum crucible. Redissolve the fused mass in hydrochloric acid, evaporate again to perfect dryness, drench the dry mass with moderately dilute muriatic acid, and after a few minutes add water. That which is left in an insoluble state is silica; separate it by filtering, wash it on the filter with water slightly acidified with muriatic acid, dry, and ignite it in a platinum crucible, and then weigh. The silica should be perfectly dry before igniting it, because a loss might otherwise be sustained by projection, and the crucible should be kept covered whilst cooling, in order that the powder may not absorb moisture. From the weight of the silica obtained, that of the silicium in the cast iron is calculated. 100 grains of silica represent 48.4 of silicium; or each grain of silica (Si O_3) contains 0.48050 of silicium.

69. The quantity of *phosphorus* is determined by dissolving a known weight of the cast iron under examination, 30 grains, for example, in aqua regia, or, better still, in nitric acid, and separating the silica by evaporation to dryness, as we just said; carbonate of potash is then added to the filtered liquor; this precipitates the phosphorus in the state of basic perphosphate of iron mixed with peroxyde of iron. The precipitate should then be treated with caustic potash, in a silver crucible, in order to transform it into phosphate of potash; water is poured upon the mass, which dissolves the phosphate of potash and leaves the peroxyde of iron in an insoluble state. The whole is thrown on a filter, and the filtrate is then supersaturated by an acid, an excess of solution of chloride of calcium is poured in, and, on adding ammonia, a precipitate of phosphate of lime is produced, from which, after ignition, the phosphoric acid is estimated. 90 grains of phosphate of lime represent 72 of phosphoric acid, or 32 of phosphorus; or each grain of phosphate of lime represents 0.55618 grain of phosphoric acid, or 0.24491 grain of phosphorus.

70. Or to the above mentioned solution of phosphate of

potash, neutralized by an acid, a known weight of recently ignited protoxyde of lead is added, the whole is evaporated to dryness, and the residuum is ignited in a small counterpoised crucible; the mass is then weighed, and from the weight thus obtained that of the protoxyde of lead employed is deducted, the remainder indicates the quantity of anhydrous phosphoric acid, 72 grains of which represent 32 grains of phosphorus, or each grain of which contains 0.43918 grain of phosphorus.

71. The quantity of *sulphur* contained in cast iron may be estimated by dissolving the cast iron in *aqua regia*, and evaporating the solution to dryness, treating the residuum with water acidified by a little nitric acid, and filtering. The peroxyde of iron is precipitated by ammonia, collected on a filter, washed, dried, and ignited. The liquor filtered from the peroxyde of iron should then be supersaturated with nitric acid, and the sulphur which has been converted into sulphuric acid, by the above treatment, is then precipitated in the state of sulphate of baryta, by pouring a solution of nitrate of baryta into the liquor. The precipitated sulphate of baryta is allowed to settle completely at the bottom of the vessel, the clear supernatant liquor is then carefully decanted and replaced by a fresh quantity of boiling water, the precipitate is again allowed to settle, and this washing, by subsidence, is repeated three or four times, in order that the precipitate may agglomerate well; the whole is then thrown on a filter, and the precipitate is finally washed, dried, ignited, and weighed. 117 grains of sulphate of baryta contain 40 of sulphuric acid, or 16 of sulphur; or each grain of sulphate of baryta contains 0.34368 grain of sulphuric acid, or 0.13747 grain of sulphur.

72. The proportion of *carbon* contained in cast iron cannot be determined by dissolving the iron in an acid, because the carbon escapes partially, and sometimes (when in small quantity or in combination) totally in the state of carburet of hydrogen.

73. One of the processes by which the quantity of carbon can be accurately determined, is that of Berthier, which consists in pulverizing or filing the cast iron to be examined (for which purpose very hard and fine files only must be used), and placing 100 grains of the pulverized iron so obtained, in a large porcelain capsule, and keeping it constantly moistened with water containing a little common salt, and exposing it to the atmosphere for 10 or 12 days. The rust or oxydized portions which will have formed should be removed every morning by trituration, or litigation, and elutriation. The portions of iron which have not been attacked are returned to the capsule, and again kept exposed, in the moist state, to the atmosphere. The whole of the iron having been thus oxydized, an excess of hydrochloric acid is added, and the whole is evaporated to dryness; hydrochloric acid is again added, and the whole is thrown on a filter and washed. The insoluble residuum is dried in a covered platinum crucible and weighed. The cover of the platinum crucible is then removed, and the residuum in the crucible is again ignited in contact with the air, in order to burn the carbon. The crucible is then weighed again; the loss indicates the quantity of carbon. The ashes left (if any) may consist of silica, or of graphite; in that case, they should be boiled with a solution of caustic potash, which will dissolve the silica, whilst the graphite will remain in an insoluble state, and its weight may then be ascertained.

“ M. Regnault proposed *another method* for the easy and accurate determination of the carbon contained in cast iron. Five grammes of cast iron reduced into filings, when it is soft, or pulverized in a mortar when it is brittle, are mixed with 60 or 80 grammes* of chromate of lead, previously fused, one-third or one-fourth of which mixture is set aside. Five grammes of chlorate of potash are then added to the remainder, which chlorate of potash contains about the quantity of

* The gramme weighs 15.4336 grains, that is nearly $15\frac{1}{2}$ grains.

oxygen necessary to convert the iron into peroxyde; and the mixture is introduced into a glass tube, similar to those employed in organic analysis, but which may be much shorter. The portion of the mixture of cast iron and of chromate of lead, which was set aside, is now added and put over the other portion in the tube, and lastly, an exsiccating apparatus, and a Liebig's apparatus for condensing carbonic acid is adapted to the tube as for performing an organic analysis. The portion of the tube which contains the mixture without chlorate is brought to a red heat, and when this is done, the operator begins to heat the portion which contains the other mixture with the chlorate, and the heat is gradually advanced in proportion as the disengagement of the gas becomes slower. By operating thus, the cast iron is first burnt almost completely by the oxygen of the chlorate, and only a very small quantity of this gas escapes from the tube. The temperature then becoming higher, the combustion is finished by the chromate of lead which, in fusing, oxydizes the last portion of the cast iron. It is advisable to wrap the glass tube in a sheet of copper, because, towards the end, the heat must be strong enough to fuse the chromate of lead completely.

“The oxydization of the cast iron is complete, which may be ascertained by triturating the mass contained in the tube after the combustion, when it will be seen that not a particle remains capable of being attracted by a magnet. The analysis is, besides, so easily performed, that it may be completed in less than half an hour.

“When cast iron contains sulphur, the latter remains altogether in the tube in the state of sulphate of lead.”

74. The proportion of *manganese* may be determined as follows :—

75. Dissolve the iron in aqua regia, with the help of heat, and after slightly supersaturating the solution with ammonia, until a few flakes of peroxyde of iron begin to appear, apply a gentle heat, in order to ascertain whether these red-

dish brown flakes will redissolve or not ; if they redissolve, it is a proof that ammonia has not been added in sufficient quantity ; more of it should therefore be poured into the solution, drop by drop, until a few flakes of peroxyde of iron which it produces are no longer redissolved by applying heat. A solution of perfectly neutral persuccinate of iron is then added to the fluid, which has a reddish brown colour, until a precipitate ceases to be produced ; heat is applied, and when the liquor has become cold the reddish brown precipitate of persuccinate of iron is collected on a filter, washed, dried, and ignited in a platinum crucible, and weighed. Should the operator chance to pour too much ammonia in the first instance, the error may be corrected by adding a few drops of muriatic acid, and stirring the whole well, and proceeding as just directed.

76. To the liquor filtered from the persuccinate of iron, carbonate of soda should now be added, and heat applied ; this precipitates the manganese in the state of carbonate of manganese, which should be collected on a filter, washed, dried, ignited by a strong heat in a platinum crucible, until it no longer diminishes in weight ; the carbonate of manganese is thereby converted into manganoso-manganic oxyde, in which state it is weighed, and each grain of which contains 0.72093 grain of manganese.

IRON FILINGS.

1. The iron filings met with in commerce are often mixed with particles of copper, the presence of which, for pharmaceutical preparations, is evidently objectionable or dangerous. These and other impurities, however, are easily separated by means of the magnet. But it is always better to purchase iron turnings instead of iron filings, for in that case the presence of copper is immediately observable.

2. The presence of copper may also be detected by pouring an aqueous solution of ammonia upon a small portion of

the filings, and stirring the mixture in contact with the air ; if the iron filings be pure, the liquor will remain colourless ; in the contrary case, it assumes a blue colour, which is so much the more intense, as it contains a larger proportion of copper.

ISINGLASS.

1. Isinglass is a glue, manufactured almost exclusively in Russia, and is made chiefly of the air bladder and sounds of different kinds of fish, especially of the sturgeon, (*Acipenter Huso*). It is the finest and best of animal glues ; the best quality is shaped like a lyre, another quality is in square pieces like the leaves of a book ; the lowest quality is of all sorts of shapes, from its having been dried without care.

2. Isinglass is used for culinary purposes, for fining beer and other liquids, for making court plaster, and stiffening silk. It should be white, inodorous, readily and completely soluble in hot water, and in cooling form a semi-transparent and solid jelly.

3. When a thin piece of genuine isinglass is looked through, by holding it before the eye and day-light, a sort of shining appearance, or *chatoiement*, may be observed.

4. Isinglass is often imitated with the intestinal membranes of the calf and of the sheep ; this spurious article may be recognized, because it does not exhibit the shining appearance before alluded to when held before the light, and because, although inodorous, it has a saltish flavour, and is generally in thinner pieces than the genuine isinglass. If it be torn asunder, it will be observed that it may be rent in all directions, whilst genuine isinglass cannot be divided otherwise than in the direction of its fibres. If a piece of artificial isinglass be macerated in water, it swells, but instead of retaining its shape, as is the case with genuine

isinglass, it becomes divided into small pieces, forming a sort of curdy precipitate ; and if treated with boiling water, about one-third of its weight is left in an insoluble state, and the liquor does not form a good jelly.

K E L P.

BRITISH BARILLA.

1. Kelp, or British barilla, is an alkali still more impure than barilla, and which is obtained in this country by burning various sea weeds. It seldom contains more than from two to five per cent. of real soda. The manufacture of kelp, like that of barilla, is almost abandoned, except as a source of iodine.—See *Ashes and Barilla*.

KUPFER-NICKEL.

PROTO-ARSENIURET OF NICKEL.

1. This mineral is the most abundant of the ores of nickel, it has a reddish colour, somewhat like copper, but it contains no copper. It is insoluble in hydrochloric acid, but it readily dissolves in nitric acid, and in aqua regia. Roasting transforms it into basic arseniate of nickel of a green colour. The constituents of this mineral are as follows :—

	Riegelsdorf.		Allamont.	Ayer Mt. Valais.
Nickel ...	44.20	48.90	48.80	43.80
Arsenic...	54.72	46.42	39.94	53.05
Iron	0.33	0.34	0.00	0.45
Lead	0.32	0.56	0.00	0.00
Antimony	0.00	0.00	8.00	0.05
Cobalt	0.00	0.00	0 16	0.32
Sulphur...	0.40	0.80	2.00	2.13
				Gangue 0.2)
	99.57	97.02	98.90	100.00
	Stromeier.	Pfaff.	Berthier.	Ebelmen.

2. The analysis of kupfer nickel is performed by first reducing the mineral into very fine powder, and boiling it

with aqua regia until the sulphur (if any separates) has agglomerated into yellow lumps which may be separated by filtering, the solution should, of course, be diluted with water before filtering, for the filter would otherwise be corroded by the acid, and the liquor would burst through. The sulphuric acid which has been produced by the action of aqua regia upon the sulphur of the mineral, and which is contained in the liquor filtered from the lumps of sulphur and other insoluble portions, should be precipitated in the state of sulphate of baryta by a solution of chloride of barium, it may then be collected on a filter, washed, dried, ignited, and weighed, 117 grains of sulphate of baryta = 40 grains of sulphuric acid, and consequently 16 grains of sulphur; or each grain of sulphate of baryta contains 0.34368 grain of sulphuric acid, or 0.13747 grain of sulphur. The lumps of sulphur which may have formed whilst boiling with aqua regia should be washed, dried, and weighed, and their weight added to that of the sulphur represented by the sulphate of baryta obtained, gives the whole proportion of the sulphur in the mineral. After having weighed the yellow lumps of sulphur they should be exposed to a red heat on a strip of platinum, or in a small platinum capsule, if pure, they will burn away without residue, in the contrary case, the residue left must be returned to that in the filter.

3. The liquor filtered from the sulphate of baryta should next be treated by dilute sulphuric acid, in order to precipitate the excess of chloride of barium employed which is separated by filtering. The arsenic acid contained in the liquor must now be converted into arsenious acid, by boiling with a large excess of sulphurous acid, which may be done as follows :—The solution is poured into a florence flask, or matrass, and a large excess of a concentrated aqueous solution of sulphurous acid is added; the flask should be inclined at an angle of about 45° , in order to avoid loss from spurting, the liquid therein is gradually raised to the boiling point, and is kept simmering at a gentle heat until all odour of

sulphurous acid has vanished; a current of sulphuretted hydrogen is then passed through the liquor until it has acquired a strong odour of the gas; the flask is then corked up and allowed to remain for about one hour in a warm place, it is then uncorked, and slowly evaporated at a gentle heat until all odour of sulphuretted hydrogen has disappeared; or else, after having left the solution saturated with sulphuretted hydrogen at rest for about an hour, as we said, a stream of carbonic acid gas may be passed through it in order to expel the sulphuretted hydrogen; in either case the last traces of sulphuret of arsenic are precipitated. The yellow precipitate which is a trisulphuret of arsenic, is collected on a counterpoised filter, washed, dried at a steam heat, and weighed. In whole numbers 124 of trisulphuret of arsenic represent 76 of arsenic, or decimally, each grain of sulphuret contains 0.60903 grain of arsenic.

4. The quantity of arsenic, however, cannot be deduced directly from the sulphuret obtained, because its composition is not definite, it contains an excess of sulphur from the partial decomposition of the sulphuretted hydrogen employed to precipitate it. After weighing the sulphuret of arsenic, as above said, it should be shaken from the filter into a large glass-beaker covered with a concave glass, or with a porcelain capsule, and treated therein with aqua regia; the counterpoised filter should then be weighed again, in order to know the exact weight of sulphuret of arsenic operated upon. The action of the aqua regia converts the sulphuret of arsenic into arsenic acid, a portion of the sulphur separates in yellow lumps, which may be weighed as pure sulphur, the other portion of the sulphur, which has been converted into sulphuric acid, is precipitated as sulphate of baryta by chloride of barium, from the weight of which that of the sulphur is calculated, as above mentioned. The collective weight of the sulphur obtained in yellow lumps, and that represented by the sulphate of baryta, gives that of the sulphuret of arsenic operated upon, and, consequently, that of the arsenic in the ore.

5. Instead of converting the arsenic acid contained in the solution into arsenious acid, by means of sulphurous acid, as we mentioned, the liquor may be precipitated at once by sulphuretted hydrogen, the only difference is in the length of time required, arsenic acid being much less readily precipitated by sulphuretted hydrogen than arsenious acid. The last traces of sulphuret of arsenic, however, may be precipitated by digesting the solution saturated with sulphuretted hydrogen at a gentle heat, until all odour of the gas has vanished.

6. To the liquor which was filtered from the sulphuret of arsenic, nitric acid should be added, and it must be concentrated by boiling, after which an excess of ammonia is added, in order to precipitate the iron in the state of peroxyde of iron of a reddish-brown colour. The liquor filtered from this precipitate is blue, and contains the nickel. As, however, this precipitate of peroxyde of iron usually retains a small quantity of nickel which has fallen down with it, it is advisable to redissolve it in hydrochloric acid, and to reprecipitate it by Fuchs' method, that is, by carbonate of baryta as follows:—The peroxyde of iron having been redissolved in hydrochloric acid, as just said, an excess of pulverized carbonate of baryta is gradually added to the solution. The peroxyde of iron falls down with the excess of carbonate of baryta in the state of a light brown precipitate, which is allowed to settle for about a couple of hours; the whole is then thrown on a filter, the precipitate is washed with hot water, and the filtrate is put by. The precipitate on the filter is then redissolved by hydrochloric acid, and the baryta is first precipitated by dilute sulphuric acid which is separated by filtering, and the liquor being treated by ammonia, the peroxyde of iron falls down in the form of a reddish-brown precipitate, which may now be collected on a filter, washed, dried, ignited, and weighed.

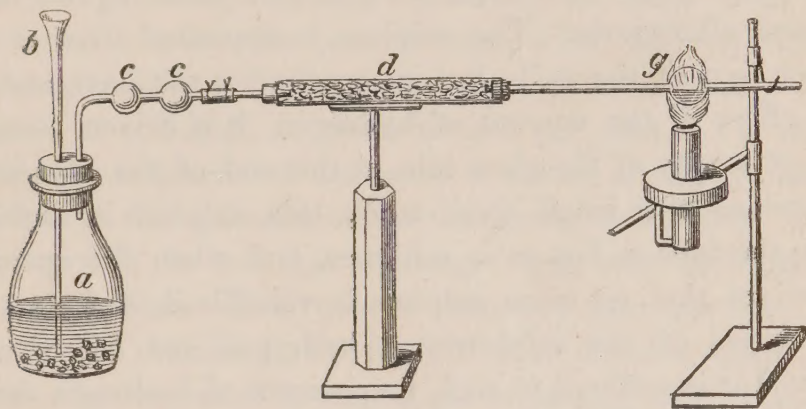
7. The liquor filtered from the carbonate of baryta, and which was put by, as above mentioned, should likewise be

treated by dilute sulphuric acid, in order to precipitate the excess of baryta in solution, and the liquor filtered from this may now be added to that which was filtered from the peroxyde of iron; both are then mixed with the blue liquor which was filtered from the peroxyde of iron in the first instance, and an excess of caustic potash is added; this produces an apple green precipitate of hydrate of oxyde of nickel, which, being collected on a filter, should be thoroughly washed with hot water, dried, ignited, and weighed.

8. When cobalt is present at the same time, it is stated that by adding hydrosulphuret of ammonia to the liquor filtered from the nickel, it will precipitate the cobalt in the state of black sulphuret; the truth is, that hydrosulphuret of ammonia will indeed produce a black precipitate of sulphuret of cobalt in that liquor, but that most of the cobalt will have been precipitated with the nickel by the caustic potash. It is erroneous to believe that potash does not precipitate cobalt from a solution containing an excess of ammonia and of ammoniacal salts; I am satisfied that whatever may be the quantity of ammonia and of ammoniacal salts, solution of caustic potash will always precipitate a large proportion, nearly the whole, of the cobalt from such a solution, and this, although well-boiled water, free from air, may have been employed. No *accurate* method of separating nickel from cobalt has yet been made known.

9. If antimony is present in the ore, it may be easily detected, because, on treating the solution by sulphuretted hydrogen as above mentioned, the first precipitate that falls down is sulphuret of antimony; it is only afterwards, and by continuing the current of the gas through the liquor that the arsenic is precipitated. If the operator wishes to determine the proportion of the antimony, he should dry thoroughly the precipitate produced by sulphuretted hydrogen, and then introduce it into a glass bulb, and heat it therein in a stream of hydrogen; a small residue of antimony is obtained.

10. This reduction of the sulphuret of antimony to the metallic state is easily effected with the apparatus in the adjoining figure :—



“ The flask *a*, contains zinc and water, and sulphuric acid is poured into it through the funnel *b*, in order to produce a slow current of hydrogen gas. The hydrogen gas escapes through a glass tube bent at right angles, and provided with two bulbs *c c*, into which the greatest portion of the moisture of the gas condenses ; in order, however, to dry it completely, it passes through another glass tube *d*, filled with chloride of calcium, and thence into the glass-bulb *g*.

“ After having dried the sulphuret of antimony upon a weighed filter, and weighed the sulphuret itself, the greatest portion of it is introduced into an accurately weighed apparatus, consisting of a glass-bulb, on each side of which a glass tube is soldered. The whole portion is introduced into the bulb, and the tubes on each side of the glass-bulb are cleaned with the feather of a pen. The apparatus is then weighed, in order to ascertain the weight of the sulphuret about to be treated. Everything being ready, a current of dry hydrogen gas is passed through the apparatus, and when filled with it, the bulb containing the sulphuret of antimony is gradually heated. If the composition of the latter is such that it corresponds to that of oxyde of antimony, the whole of the sulphur is converted into sulphuretted hydrogen, and

the antimony remains ; if, on the contrary, it is a higher degree of sulphuration, or a mixture of several degrees of sulphuration, there remains metallic antimony likewise, but sulphur is first sublimed, and sulphuretted hydrogen is formed afterwards. The sulphur is deposited first at the upper part of the bulb, but on continuing the heat, and by the effect of the current of hydrogen, it is driven towards the extremity of the glass tube at the end of the apparatus. By means of a small spirit-lamp, this sulphur is expelled from the tube as fast as it sublimes, and when the operator perceives that no more sulphur is volatilized, and that the production of the sulphuretted hydrogen has ceased, the apparatus is suffered to cool, the current of hydrogen being continued during the time. When the apparatus has completely cooled, it is taken to pieces, and the loss of weight was sulphur, the remainder is antimony.

“ When it is wished to convert sulphuret of antimony into metallic antimony, by means of hydrogen gas, the heat is removed, when, upon lighting the gas, the odour of sulphurous acid ceases to be smelt, or better still, when, by holding a glass rod, moistened with ammonia, at a short distance from the flame, no white clouds are produced.

“ This method gives an accurate result only when the experiment is performed with the requisite care. It is impossible to prevent the sublimation of a small portion of antimony, which deposits at the upper part of the bulb, and which penetrates even into the tube, when the heat employed in the operation has been strong. If, on the contrary, the heat is too feeble, the sulphur is not totally expelled from the sulphuret of antimony. Moreover, the hydrogen really carries away an extremely slight quantity of antimony, owing to which, it burns towards the end with an almost imperceptible fume of antimony, which deposits very slight traces of oxyde of antimony at the orifice of the tube at which the gas is inflamed. In consequence of this, it generally occurs that in most analyses, the operator obtains a

little less antimony, and a little more sulphur than should be, because the quantity of the sulphur is calculated from the loss of weight. The quantity of antimony thus lost does not generally amount, however, to more than one quarter of a hundredth part at most, when the experiment has been conducted with proper care ; with less care it may amount to one half, or even to one per cent. The more slowly the sulphuret of antimony is heated at the beginning the less is the quantity of the antimony volatilized. It is only towards the end that a stronger heat must be employed for a short time. The reduced antimony does not fuse into a lump, but remains in the form of small metallic grains. If, whilst the current of hydrogen gas is passing, the sulphuret has been gently heated for a long time, the antimony reduced presents crystalline facets, the lustre of which makes the antimony appear of a blacker colour than that reduced under the influence of a stronger heat."

11. If, however, the operator, neglecting the other constituents, wishes to determine only the quantity of nickel contained in the ore, he should proceed as follows :—

1st. Reduce the mineral into fine powder, and introduce a given weight of it in a flask.

2nd. Pour aqua regia upon the pulverized mineral in the flask, and apply heat until any sulphur which may be liberated has collected into small lumps, dilute with water, and filter. The aqua regia should be poured into the flask in very small portions at a time, or else the reaction will be too violent, the mass will intumescence and be violently projected.

3rd. Pour a solution of chloride of barium in the filtrate, and separate the precipitate so produced by filtering.

4th. Add dilute sulphuric acid to the filtrate of operation 2nd, in order to separate the excess of chloride of barium employed, and filter.

5th. Pour a large excess of a concentrated aqueous solution of sulphurous acid into the liquor, and bring the whole to

the boiling point until the odour of sulphurous acid has disappeared, in order to convert the arsenic acid into arsenious acid, and pass a stream of sulphuretted hydrogen through the solution. The addition of sulphurous acid may be dispensed with, and the stream of sulphuretted hydrogen may be at once passed slowly through the solution, but the whole should then be left at rest in a warm place for several hours, until the odour of the gas has disappeared. The precipitated sulphuret of arsenic is then separated by filtering, and washed.

6th. The liquor filtered from the sulphuret of arsenic (and of antimony) is then mixed with nitric acid, concentrated by boiling, and caustic ammonia is then added, in order to precipitate the peroxyde of iron. The precipitate is separated by filtering, and the filtrate which is blue, and contains nearly all the nickel, is treated as at 8, the operation below.

7th. The precipitated peroxyde of iron which contains a trace of nickel is redissolved in hydrochloric acid, and an excess of pulverized carbonate of baryta is gradually added; the whole is left at rest for two hours; the precipitate is collected on a filter, redissolved by hydrochloric acid, and the baryta is precipitated by dilute sulphuric acid and filtered; the filtrate is treated by an excess of ammonia, which precipitates the peroxyde of iron; it is collected on a filter, and washed.

8th. The ammoniacal liquor filtered from the precipitated peroxyde of iron is mixed with the other ammoniacal liquor of 6th operation, which was kept for the purpose, and the two liquors being now treated by a solution of caustic potash, the oxyde of nickel is precipitated, collected on a filter, washed with hot water, dried, ignited, and weighed.

LAC.—See *Shellac*.

LAC DYE.

1. Lac dye is a red colouring matter extracted from stick lac in various ways. The best is manufactured from the stick lac of Siam and of Pegu; it is in pieces about $2\frac{1}{2}$ or 3 inches square, and half an inch thick, of a dark purple colour. The best is marked D T, the second J Mc R, the third C E, but as these marks are imitated, it is much better not to rely upon them, but to determine the quantity of colouring matter or the tinctorial power of the article, which is done by comparison, dyeing a certain portion of wool, cloth, or flannel, as described below, and comparing the colour with that produced in the same conditions by genuine and best lac dye.

2. The dye bath is prepared as follows :—

5 grains of cream of tartar (argol),
20 grains of flannel, or white cloth,
5 grains of lac dye,
5 grains of chloride of tin,
1 quart of water.

3. The following proportions may also be used :—

5 grains cream of tartar (argol),
60 grains of white cloth or flannel,
5 grains of lac dye,
1 pint of water.

4. Heat the water to the boiling-point in a tin or china vessel; add thereto the cream of tartar (argol), and then the piece of cloth or of flannel, previously weighed. Weigh off 5 grains of the lac dye, and pulverize it in a Wedgewood mortar with the 5 grains (by measure) of chloride of tin, and pour the whole into the hot liquor containing the argol and the cloth, taking care to rinse the mortar with a little of the hot liquor; keep the whole boiling for at least one quarter of

an hour, or even half an hour, stirring the cloth or flannel about by means of a glass or of a wooden stirrer. At the end of that time the cloth should be withdrawn, washed in cold water, and then dried.

LAC LAKE.

5. Lac lake is a colouring matter obtained also from stick lac, but is much inferior to lac dye. The process for estimating its strength, and consequently, its commercial value, is the same as we described for lac dye.

LANA PHILOSOPHICA.—See *Oxyde of Zinc*.

LAPIS INFERNALIS.—See *Nitrate of Silver*.

LEAD ORES.—See *Galena*.

LIME.

1. Lime is the principal constituent of all calcareous building stones, and is employed also in the preparation of mortars and cements. Ordinary mortars are mixtures of lime and of quartzose sand; after exposure to the air they become very hard, but are completely desaggregated by immersion in water. Those mortars and cements, on the contrary, which become very hard by immersion in water, are called hydraulic. Hydraulic mortars and cements are principally mixtures of lime and clay, in proportions which render them more or less susceptible of hardening in water; according to Berthier, their composition is as follows :—

COMPOSITION OF HYDRAULIC LIME-STONES.

Moderately Hydraulic.				Very Hydraulic.			
Carbonate of lime...	89.2	85.8	83.0	82.5	76.5	80.0	72.5
Do. of magnesia...	3.0	0.4	2.0	4.1	3.0	1.5	4.5
Do. of iron	„	6.2	„	„	3.0	„	„
Do. of manganese.	„	„	„	„	1.5	„	„
Clay or silica.....	7.8	7.6	15.0	13.4	15.2	18.5	23.0

2. As the preparation of hydraulic mortars depends on the composition of the lime-stone employed, it is important to determine by analysis the constituents of the lime-stones intended for the purpose, this may be done in the following manner :—

3. Take a given weight, for example, 50 grains of the lime-stone to be examined, and dissolve them in hydrochloric acid diluted with half its weight of water. The lime, magnesia, and oxyde of iron will dissolve, whilst the clay and the silica being left in an insoluble state, may be collected on a filter, washed, dried, ignited, and weighed. This exceedingly simple examination is ordinarily sufficient to judge of the quality of the hydraulic lime which may be produced from it.

4. If the operator wishes to determine the proportion of the other constituents, the acid solution filtered from the clay and sand, as above said, should be supersaturated with ammonia, which will precipitate the iron in the form of a bulky reddish-brown precipitate, which should be collected on a filter, washed, dried, and ignited. The bulk of the precipitate shrinks enormously in drying, and when dry it should be gradually ignited in order to avoid decrepitation.

5. The filtrate, which contains a great excess of sal ammoniac resulting from the supersaturation of the acid liquor with ammonia, is then treated by oxalate of ammonia, which precipitates the lime in the state of oxalate of lime. This salt may be collected on a filter, washed, and calcined

with an excess of sulphuric acid, and from the sulphate of lime obtained, the weight of the lime in the lime-stone is calculated; 68 grains of sulphate of lime contain 28 grains of lime, or decimally, each grain of sulphate of lime represents 0.41176 grain of lime; or the precipitated oxalate of lime may be ignited as described page 146, § 14, and weighed as carbonate of lime.

6. Lastly the *magnesia* is determined by boiling for a long time the liquor filtered from the oxalate of lime with carbonate of potash until ammonia ceases to be evolved, by which treatment the magnesia is gradually precipitated in the state of carbonate of magnesia. This precipitate should then be collected on a filter and washed with hot water. The washing should not be continued too long, because carbonate of magnesia is not quite insoluble in water. The precipitate is then dried, strongly ignited for a pretty long time, in order to expel the carbonic acid; what is left is pure magnesia, which may then be weighed.

7. When the operator wishes to determine the proportion of lime in a *mixture of caustic lime and of carbonate of lime*, it may be done in a very simple manner, by mixing a given weight of the sample with a sufficient quantity of sal ammoniac, which is decomposed by caustic lime into free ammonia and chloride of calcium, whilst it has no action upon the carbonate of lime. It is therefore evident, that if we now determine the quantity of ammonia liberated, we shall know the proportion of caustic lime present in the sample. The sample of lime should therefore be pulverized, one part, in weight, of it should be mixed with at least two parts of sal ammoniac, also in fine powder, and the whole introduced into a combustion-tube connected with a Liebig's or Warrentrap's condenser, as described before, see p. 272, § 34, the bulb condenser being filled with a known quantity of test-muriatic acid, 1000 grains-measures of which represent exactly 17 grains of ammonia, corresponding to 28 grains of caustic lime. If the mixture consisted of caustic lime, and of

carbonate of lime, the difference between the quantity of caustic lime represented by the ammonia evolved, and the weight of pulverized lime employed, indicates, of course, the quantity of carbonate of lime.

8. Or else the proportion of the carbonate may be determined in the manner which has been described in the article on *Manganese*, and also in that on *Acidimetry*, by the quantity of carbonic acid evolved, either by Fresenius and Will's apparatus, or by that of Mr. Parnell. 22 grains of carbonic acid represent 50 of carbonate of lime; or each grain of carbonic acid evolved represents 2.272 of carbonate of lime, the rest being caustic lime.

9. M. Bineau described ("Mémoire de la Société Royale d'Agriculture et Arts utiles de Lyon, April 30, 1847,") an analytical process for the speedy estimation of the carbonate of lime contained in lime-stones, marls, agricultural soils, and in water, as follows:—

10. If the substance is solid, the portion on which the experiment is performed, should be finely pulverized, and introduced into a tubulated retort; a known weight of hydrochloric acid should then be poured upon it, in a greater quantity than is sufficient to decompose the carbonate. The whole is then heated until a few drops of the vapour begins to condense in the neck of the retort; when this is observed, a tubulated receiver is connected with the neck of the retort, and the boiling is resumed. If the operation is conducted as described, the quantity of carbonic acid absorbed by the distillate may be neglected. The boiling having been continued long enough to ensure complete re-action, the liquids in the receiver and in the retort are mixed together, tinged red with tincture of litmus, and the operator pours then into the liquor, from an alkalimeter, a test-solution of alkali of a known strength until the solution becomes blue, exactly as in *Acidimetry*. The number of divisions employed are read off, and the quantity of lime or of carbonate of lime is thus at once ascertained. This method thus limited, however, is not

so accurate as the one mentioned before ; but for practical purposes it will, I dare say, be found available.

11. If the lime-stone is a *magnesian lime-stone*, the operation should be modified, for the proportion of magnesia must, in that case, be determined. Wherefore sugar and water should be added, and a fresh portion of the test alkaline solution should be poured in the liquor as long as a precipitate continues to be produced. The sugar and water keep the lime in solution, the magnesia alone being precipitated, and its proportion or that of its carbonate is estimated from the number of divisions which have been poured from the alkali-meter in this second part of the examination.

12. If the operator have accidentally poured more of the alkaline test-liquor than was requisite, the mishap is easily remedied by estimating the excess of acid so employed, by means of a sulphuric acid test-liquor of a known strength. The magnesia precipitated as above directed, is collected on a filter, and the sulphuric acid test-liquor is carefully poured into the filtrate, in order to determine the excess of alkali which may have been used.

13. In all cases, in order to know the proportion of the lime, it is necessary to subtract from the acid employed at the beginning of the experiment, not only that which corresponds to the number of divisions of the alkaline test-liquor employed to neutralize the acid, but likewise that which corresponds to the number of divisions of the alkaline test-liquor which were subsequently employed to precipitate the magnesia.

14. And, moreover, in order to determine the quantity of the magnesia, it is necessary (on account of its being slightly soluble) to operate only on a small quantity of liquid. The presence of sugar or of an alkaline salt does not increase the solubility of magnesia.

15. The presence of alumina and of iron does not interfere with the accuracy of the analysis.

16. If the carbonate of lime to be estimated is in solution

in water, and if carbonate of potash, or of soda, or other salts, with an alkaline re-action, or organic matters capable of yielding ammonia are likewise in solution, conjointly with the carbonate of lime, it is necessary first to precipitate the latter by a protracted ebullition, which may be conveniently effected in the vessel in which the liquid is contained. The precipitate is then washed, and treated in the manner which has been described. As to the small portion which has not fallen down, and is therefore still retained in solution, its quantity is approximatively determined by admitting that each decilitre (6.11208 cubic inches) of water retains in solution 4 milligrammes (1 milligramme is 0.0154 grain) of the carbonate sought for.

17. If the water which contains the carbonate of lime is free from other substances capable of neutralizing acids, an excess of test-acid is added to it immediately and before pouring the alkaline test-liquor by which the excess of acid has to be determined ; the carbonic acid must be expelled by boiling. As the free acid left is extremely diluted, the imperceptible quantity which evaporates may be neglected ; besides, sulphuric acid may be employed instead of hydrochloric acid.

LINEN.—See *Cotton*.

LINSEED MEAL.

1. The linseed meal of commerce is frequently adulterated with *bran*, *saw-dust*, *clay*, &c. According to Soubeiran, the presence of *bran*, which is the substance most ordinarily employed for adulterating it, may be detected by means of a solution of iodine, which produces the characteristic blue colour. Yet it should be remembered that pure linseed contains a small quantity of starch, and that it often accidentally contains also small grains of corn, which, unless indeed the

blue colour produced by the iodine is very deep, might easily lead into error.

2. The best test, however, consists in exhausting the meal with ether, and evaporating the ether ; good and pure linseed meal should thus yield 53 per cent. of oil.

LIQUEURS.—See *Blanc Mange*.

LITHARGE.

PROTOXYDE OF LEAD. MASSICOT.

1. Litharge (protoxyde of lead PbO) is known also under the name of *massicot*, when it has not undergone fusion ; after fusion it is always called *litharge*.

2. Commercial litharge, especially that which is foreign, such as that of Hamburgh, contains sometimes a considerable proportion of *oxyde of copper* and of *iron*, sometimes also a little *silver* and *silica*. Litharge is sometimes met with in coherent masses, of a yellowish colour, in which case it is sometimes called *litharge of silver* ; at other times it consists of a multitude of beautiful semi-transparent spangles, of a reddish colour, in which case it is called *litharge of gold*, and often contains a certain quantity of minium.

3. As litharge slowly absorbs the carbonic acid of the air, it generally effervesces when treated by acids, and this effervescence is stronger in proportion to its age.

4. The best solvent of litharge is nitric or acetic acid. When these acids fail in dissolving it completely, it is a proof that it is not pure. The principal impurity generally is silica, which thus remaining undissolved, may at once be estimated by weighing, of course after drying it.

5. If the litharge under examination contains any *iron*, *copper*, or *silver*, which is often the case, these substances may be detected by dissolving a known weight of the litharge in nitric acid diluting with a very large quantity of water, and

adding hydrochloric acid, which will produce a white precipitate of chloride of silver, if that metal be present; or instead of hydrochloric acid, a solution of chloride of sodium (common salt) may be used, as described in the article on silver, to which the reader is referred. Or instead of a solution of chloride of sodium, one of chloride of lead may be employed as a test for the silver; in that case, 140 grains of chloride of lead should be dissolved in 10,000 grains-measure of water, 1000 grains of which will represent 10.8 of silver.

6. After having separated the chloride of silver produced, by filtering, a current of sulphuretted hydrogen should be slowly passed through the filtered liquor, until it smells strongly of the gas; this precipitates the lead and the copper in the state of black sulphurets, which should be collected on a filter, washed, and then cautiously treated by fuming nitric acid, which should be added in small portions at a time, to avoid too violent an action, which might cause a loss by projection, and on which account the vessel should be covered by a watch glass or a porcelain capsule. The whole is then evaporated to dryness, and the sulphate of copper produced is separated from the sulphate of lead by treating the slightly ignited residuum with water, which redissolves the sulphate of copper. The sulphate of lead left in an insoluble state should be moderately heated until acid vapours cease to be disengaged, it is then ignited and weighed. 152 grains of sulphate of lead contain 104 of lead, or 112 of protoxyde of lead; or decimally, each grain of sulphate of lead contains 0.73563 grain of protoxyde of lead, or 0.68287 grain of lead.

7. The presence of copper may be ascertained in the filtered solution by ammonia, which will produce a blue colour, or better still, by ferrocyanuret of potassium, which will produce a reddish-brown precipitate. If so, the copper may now be precipitated from the liquor filtered from the sulphate of lead, in the manner described in the article on sulphate of copper, by means of a solution of potash.

8. As to the liquor which was filtered from the sulphurets of lead and of copper produced by sulphuretted hydrogen, it should be boiled, in order to expel all the sulphuretted hydrogen, an excess of ammonia being then added will precipitate the peroxyde of iron in the form of reddish-brown flakes, very bulky, and which being collected on a filter, and washed thereon, may then be dried, ignited, and weighed. The heat should be applied very carefully at first, for the precipitate might otherwise decrepitate, and a loss be sustained in consequence.

LOZENGES.—See *Blanc Mange*.

LUMP LAC.—See *Shellac*.

LUNAR CAUSTIC.—See *Nitrate of Silver*.

M A D D E R.

1. Madder is the root of a plant (*rubia tinctorum*) of which there are several species.

2. *Levant madder* occurs in commerce in pieces externally brown, and internally of a pale orange yellow colour; the roots ordinarily sold in shops belong to this species.

3. *Dutch* and *Zealand madder* is also very much in request; the roots are generally met with in the pulverized state, because they are ground for importation.

4. *Avignon*, or *French madder*, is imported both whole and ground.

5. *Munjeet* is a species of madder imported from East India.

6. Madder is sometimes called *alizari*, which is the name

given to all kinds of unground madder; *Gamene madder* (garance robée) is madder which has been dried and ground without removing the outer pellicle; *kor*, *krups*, or *crops*, *grappe*, is ground madder from which the outer pellicle has been removed; *mull madder* is the worst kind of madder, and it consists of the pieces which have been separated by fanning or sifting, and pulverizing the smaller roots of the other kinds; it is suitable only for the darker reds.

7. According to Bucholz the constituents of madder are as follows :—

Resinous red colouring matter	1.2
Extractive ditto	39.0
Reddish-brown substance soluble in alcohol	1.9
Pungent extractive	0.6
Gummy matter	9.0
Woody fibre	22.5
Matter soluble in potash	4.6
Salts of lime with colouring matter	1.8
Water	12.0
Loss	7.4
	100.0

8. According to M. Ed. Kœchlin, madder root, in the fresh state, consists of—

90.36 fleshy parts =	{ water	73.42
	{ dry matter	16.94
9.64 woody fibre =	{ water	4.96
	{ dry matter	4.68
100.00		100.00

9. The same chemist says that ground and dried madder root contains—

Matter soluble in cold water	.	.	55.0
Ditto in boiling water	.	.	3.0
Ditto in alcohol	.	.	1.5
Woody fibre	.	.	40.5
			100.0

10. According to Chevreul, 100 parts of Levant or Turkey madder, dried at 212° Fahr., yielded 9.8 of ashes half fused.

100 parts of madder from Alsatia yielded 9.5 of pulverulent ashes.

100 parts of another sample, also from Alsatia, yielded 12.0 of pulverulent ashes.

100 parts of a third sample of madder from the same country, yielded 13.5 of pulverulent ashes.

11. Madder is often adulterated with *brickdust, red ochre, red sand, clay, mahogany sawdust, logwood, sandal and japan-wood, bran.*

12. The fraudulent admixture of brick-dust and other earthy or silicious matter, may be easily detected by putting a portion of the sample into a large precipitating glass, and stirring it therein with about 100 or 150 times its weight of water. The madder remains suspended in the liquid, and by decanting it with suitable care, again adding water, stirring, and decanting again and again several times, nearly the whole of the earthy impurities may be separated. It is better, however, to incinerate a given weight of the madder under examination, and to compare the weight of the ashes thus obtained, with those which are left when genuine madder of the same description is submitted to the same ordeal.

13. According to Messrs. Girardin and Houtou La Billardièrè, genuine madder, perfectly dried, at 212° Fahr., and from which the epidermis and all earthy matter has been removed, leaves, on an average, 5 per cent. of ashes. The

madder of Provence with its epidermis, yields 8.80 per cent of ashes.

14. The estimation of *sawdust*, *bran*, and other such organic matter is more difficult, and the best way is to ascertain the tinctorial power of the sample under examination. This, according to Robiquet and Collin, may be done in the following manner:—dry the sample or samples at a steam-heat, take 25 grammes (about 400 grains) of each sample, and treat them by 200 or 250 grammes (about 3 or 4,000 grains-measure) of water, the temperature of which should not exceed 20° cent. (68° Fahr.), for otherwise a portion of the red colouring matter would be dissolved. The whole, after having been left in contact for about three hours, is thrown upon a filter, the insoluble portion is washed with 200 or 250 grammes (3 or 4,000 grains-measure) of cold water, after which it is dried at a steam heat, and weighed.

15. One part of the insoluble matter is then put into a small glass-balloon, with 40 parts of water and 8 parts of alum; the whole is heated, and after boiling for a quarter of an hour, the liquor is filtered whilst in the boiling state. The insoluble portion is again washed, as before, and the filtrate from the various samples is precipitated by sulphuric acid. The weight of the precipitate so produced in each liquor represents the proportion of colouring matter contained in them.

16. This process is based upon the insolubility of alizarine in cold water, whilst the boiling solution of alum dissolves it all. Chevreul, however, says that a portion remains undissolved.

17. *A. Meillet's process*.—Take 20 litres* of water (about 4½ gallons) heated to 60° cent. (140° Fahr.), and dissolve therein 2 kilogrammes (about 4½ lbs.) of alum; add thereto 10 kilogrammes (about 22 lbs.) of madder, bring the whole

* The *litre* is 1.076 pint; the *kilogramme* is 2.20 lbs.

gradually to the boiling point, and keep it boiling for half an hour. The decoction is then thrown upon a cloth filter, and strongly squeezed thereon; after having repeated this treatment three times, the madder is exhausted. The various filtrates are mixed together and left at rest for a while, the clear portion is decanted, and before it has completely cooled, the operator pours into it 625 grammes (about 10,000 grains-measure) of sulphuric acid of sp. gr. 1.848, diluted with twice its bulk of water, taking care to stir the liquor incessantly whilst pouring the acid. Thick reddish flakes are precipitated, which very soon settle at the bottom, and the liquor from purple-red becomes greenish-yellow. The supernatant liquor is then decanted, the residuum is washed several times, and a mass is left which, after drying in the air, is in the state of shining scales of a reddish-brown colour; it is *alizarine*, but not quite pure. The precipitate, whilst still moist, should be heated with one and a half its weight of carbonate of potash dissolved in 12 or 15 times its bulk of water; the carbonate of potash is then saturated by sulphuric acid which produces a precipitate of a fine red colour, which, according to Mr. Meillet, is pure alizarine. The madder from Avignon, when submitted to this treatment, yields 2 or $2\frac{1}{2}$ per cent. of alizarine; but it is necessary in such trials to compare the result obtained with that given by madders of the same kind and name, which are known to be genuine.

18. Madder may also be tried by Houtou la Billardièrè's colorimeter. (This instrument has been described in the article on *Indigo*.) The experiment is performed as follows:—First dry thoroughly at 212° Fahr., a portion of madder of a known quality, and a like weight of the sample of madder to be examined. This done, take 500 grains of each of these two portions, and mix them carefully with ten times their weight of water at 68° Fahr., and leave the whole to digest for three hours. Repeat the same operation a second time, and wash both residues with 5,000 grains-

measure of water, and dry them as before. The loss indicates the weight of the gummy and saccharine matter contained in the respective samples. Introduce now 100 grains of the two samples of madder, each in a glass balloon, with 800 grains-measure of water and 100 grains of very pure alum, (see *Alum*), boil the whole for a quarter of an hour and filter the decoction whilst boiling. Wash the residuum with 50 grains-measure of water. Repeat this operation three times, and mix the three decoctions of each respective sample together. By means of the colorimeter it is then easy to appreciate the different intensity of colour, for if 100 parts of the mixed decoction of each sample be introduced into the tubes of the colorimeter, and water added to that which has the deeper tinge, until it is brought exactly to the degree of intensity of the other, the graduations on the tubes will at once indicate in what ratio they differ.

19. But as madder is often adulterated with pulverized dye-woods, such as logwood, Brasil-wood, &c., other trials should be simultaneously resorted to. They consist in dyeing with a given weight of pulverized madder, known to be of superior quality, a certain quantity of cotton prepared with different mordants. The pieces of calico employed for the experiment should all be of equal weight, and about two and half or three inches square, and they should be dyed with increasing proportions of pulverized madder, from 10 grains to 150 grains; a scale of intensity of colour is thus prepared with each mordant, the degrees of which scale correspond to a known weight of the madder taken as type.

20. The dyeing must be performed with care as follows:—Take a suitable number of wide-mouthed flasks, and put them into a pan placed over a naked fire, and containing water at 100 or 104° Fahr. Pour into each of the flasks 1½ pint of distilled water, also a piece of the mordanted piece of calico, and the quantity of madder required. Put a thermometer into the pan which should now be carefully heated, avoiding variations of temperature, and in such a way that

an hour and a half may elapse before the bath attains 167° Fahr. Raise then the temperature to the boiling point for half an hour. The samples of calico are then withdrawn, rinsed with cold water and dried.

21. The dyed pieces of calico are then divided into two equal portions, one half is preserved in that state, the other half is immersed for half an hour at 106° Fahr., in a solution of soap, consisting of 25 grains of white curd soap, and 1½ pint of water; the tissue is then withdrawn, rinsed with cold water, and returned to a soap-bath prepared as the above, but to which 8 grains of chloride of tin have been added. This bath is kept boiling for half an hour. The piece of calico should be carefully rinsed, dried, and kept sheltered from the light.

22. After having prepared a scale of colours as above directed, it is sufficient afterwards, in order to determine the value of a sample of madder, to dye pieces of calico of the same description, with known weights of the madder under examination, and this value, compared with that taken as type, is then easily determined.

23. Instead of pieces of calico, skeins may be employed weighing 150 grains, for which from 300 to 450 or 500 grains of pulverized madder are used to form a scale of ten colours.

24. *Alizarine* or *garancine* may be tested in the same manner.

M A G N E S I A.

CALCINED MAGNESIA.

1. Magnesia is the oxyde of a metal called magnesium; when pure it is white, pulverulent, very light, soft to the touch, and odourless; its specific gravity is 2.3.

2. The magnesia which occurs in commerce is often adulterated to a considerable extent with *lime*, *alumina*, and *silica*; sometimes also it contains *carbonate of magnesia*,

which latter substance is often altogether substituted for calcined magnesia.

3. Pure magnesia, however, should not produce any effervescence when treated by an acid; for example, hydrochloric acid. If it effervesces, it is a proof of careless preparation, the whole of the carbonic acid not having been expelled, or of adulteration with some other carbonate. The acid employed for the purpose should be diluted with water before pouring it upon the magnesia, which should be dissolved thereby without any residue whatever; all that which may remain undissolved is an impurity. It sometimes happens, however, that a residue is apparently left though the magnesia may be quite pure, this occurs when the heat employed in calcining the magnesia has been too strong or protracted for too long a time, in which case it dissolves entirely in acids, but it takes a long time.

4. If the clear solution containing an excess of acid produces a white flocculent precipitate, insoluble in solution of sal ammoniac, it is *alumina*, which should be rapidly filtered; and if the liquor filtered therefrom, being tested by oxalate of ammonia, produces a precipitate, it is *oxalate of lime*, and, of course, the magnesia contained that earth. The precipitated oxalate of lime may be collected on a filter, washed, dried, ignited, and weighed as carbonate of lime, into which ignition has converted it. Each grain of carbonate of lime represents 0.56 grain of lime.

5. The hydrochloric acid solution of magnesia should not be precipitated by solution of chloride of barium; if a precipitate is produced a sulphate is present; the precipitated sulphate of baryta so produced, may be collected on a filter, washed, dried, ignited, and weighed. 117 grains of sulphate of baryta represent 1 equivalent, or 40 grains of pure anhydrous sulphuric acid, and consequently 1 equivalent of any sulphate; in that case an insoluble residuum will most probably have been left when treating the magnesia with hydrochloric acid, as mentioned before. If silica was present, it will have been left also in an insoluble state.

CARBONATE OF MAGNESIA.

6. Commercial carbonate of magnesia is in small cubic lumps, of a fine white colour, soft to the touch, inodorous, tasteless, and of a specific gravity of 0.294.

7. This substance is often contaminated by *carbonate of lime* (chalk), which either has been fraudulently mixed with it, or because the magnesian salts from which it has been obtained were naturally contaminated with salts of lime, as is the case, when prepared from the mother-waters used in the manufacture of nitre, and of common salt. The best is that obtained by precipitating a solution of sulphate of magnesia by one of carbonate of potash or of soda.

8. The presence of *carbonate of lime* is detected by dissolving a portion of the carbonate of magnesia under examination in hydrochloric acid, filtering, saturating the excess of acid with aqueous solution of ammonia, and then adding a solution of oxalate of ammonia, which will then produce a precipitate of oxalate of lime. The precipitate should be rapidly collected on a filter, washed, and calcined in a platinum crucible; the weight is that of the carbonate of lime contained in the substance.

MAILLECHOR.—See *German Silver*.

MANGANESE.

1. The principal ores of the manganese are the—

Pyrolusite (deutoxyde of manganese) }	Mn O ₂
Braunite (sesquioxoide of manganese)	Mn ₂ O ₃
Manganite (hydrated sesquiox. of manganese)	Mn ₂ O ₃ + HO
Hausmanite (red oxyde of manganese)	Mn ₃ O ₄

2 The first of these ores, or pyrolusite, is the most impor-

tant, and as the natural ores of manganese are mixtures of this with the lower oxydes of manganese, and certain impurities, such as *earthy carbonates, peroxyde of iron, alumina, silica, sulphate of baryta, &c.*, it is absolutely necessary that the manufacturer who uses this mineral should ascertain the quantity of peroxyde of manganese contained in the ore, for the proportion which the said peroxyde bears to the rest of the sample determines its commercial value.

Estimation of the proportion of peroxyde of manganese contained in the ores of manganese.

3. This estimation of the commercial value or of the quantity, of peroxyde of manganese, may be accomplished in various ways :—

4. First reduce into fine powder the sample which has to be examined, and treat it by dilute nitric acid. If this produces an effervescence, it is owing to the presence of carbonates, and should be left to digest in the acid until all the carbonates have dissolved, after which the whole should be thrown upon a filter, washed, and dried. For technical purposes, the weight of these carbonates may be easily and readily effected by weighing a certain quantity of the sample, for example, 100 grains, digesting it for a long time in dilute nitric acid, collecting on a filter, washing, and drying, until it no longer diminishes in weight. The loss indicates the quantity per cent. of the carbonates which it contained.

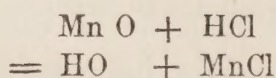
5. This being done, take a weighed quantity of the sample, dry it well, as just said, and introduce it into a small counterpoised retort, at the extremity of which a tube, containing fragments of fused chloride of calcium, also weighed, should be adjusted. Apply then to the retort the strongest heat that can be produced by an argand spirit-lamp, and after some time, disconnect the chloride of calcium tube, and weigh it. The increase of weight indicates the quantity of

water which has volatilized, and which was yielded principally by the hydrate of sesquioxide (manganite $\text{Mn}_2\text{O}_3 + \text{HO}$) some portion of which is always found mixed with the peroxyde. 100 grains of water thus evaporated correspond to 981.76 of manganite.

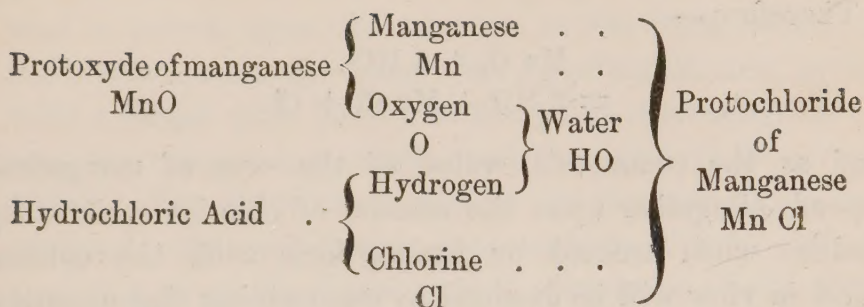
6. The contents of the small retort should now be emptied into a counterpoised platinum capsule or crucible, and ignited therein, until, after repeated weighings, the weight is observed to remain uniform ; this converts the mass completely into manganoso-manganic oxyde (Mn_3O_4). The crucible is then weighed, and the loss indicates the quantity of oxygen evolved, from which that of the peroxyde is calculated. Each grain of oxygen corresponds to 8.1885 of pure peroxyde. This experiment should evidently be carried on with great care, since a small quantity of oxygen represents a large quantity of peroxyde. In order to effect the complete conversion of the peroxyde in the sample into red oxyde of manganese, as above mentioned, the ignition should be continued for a long time, and the quantity operated upon should be small ; if a larger quantity be treated, a common fire should be used instead of an argand lamp.

7. *Another method* consists in estimating the quantity of chlorine evolved from a given weight of the sample when treated by hydrochloric acid.

8. In order to understand the rationale of this experiment, we should bear in mind, that all the oxydes of manganese when heated in contact with hydrochloric acid, evolve a quantity of chlorine exactly proportionate to that of the oxygen, above that which is contained in the protoxyde ; for example, protoxyde of manganese being treated by hydrochloric acid, produces only protochloride of manganese and water, but yields no free chlorine, as shown by the following equation :—

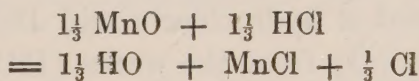


Or thus—



9. Not so, however, the *red oxyde of manganese*, or *manganoso-manganic oxyde*, which when treated by hydrochloric acid forms protochloride of manganese, but disengages one-third of an equivalent of chlorine, as shown by the following equation.

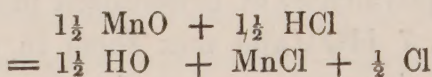
Red oxyde of manganese, or manganoso-manganic oxyde may be represented by formula $Mn\ O + Mn_2\ O_3$, or $Mn_3\ O_4$, or $3Mn\ O_{1\frac{1}{3}}$, therefore—



Sesquioxide of manganese, when treated by hydrochloric acid, yields half an equivalent of free chlorine for each equivalent of protochloride of manganese formed, as shown by the following equation.

Sesquioxide of manganese, $Mn_2\ O_3$, is the same as $2\ Mn\ O_{1\frac{1}{2}}$,

Therefore—

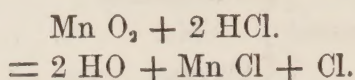


10. Lastly, peroxyde of manganese, when treated by hydrochloric acid, yields one entire equivalent of chlorine for each

equivalent of protoxyde formed, as shown by the following equation.

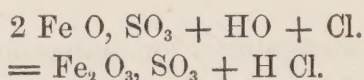
Peroxyde of manganese is Mn O_2

Therefore—



And as the commercial value of the ores of manganese depends altogether upon the amount of chlorine which they produce when treated by hydrochloric acid, the evident object in view will be attained by determining that quantity.

11. *Runge's method* for the analysis of chloride of lime, described in our article on chlorimetry, may be employed for the purpose. That method is based upon the rapid peroxydization which sulphate of protoxyde of iron undergoes when in contact with chlorine, water being present; this reaction is represented by the following equation.

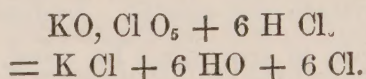


That is to say, one equivalent of chlorine (Cl) combines with one equivalent of hydrogen (H) from the water (HO) to form one equivalent of hydrochloric acid HCl, whilst the equivalent of oxygen (O) from the water (HO) being thus liberated, adds itself to the two equivalents of protosulphate of iron (2Fe O, SO_3), which become thus converted into sulphate of peroxyde of iron ($\text{Fe}_2 \text{O}_3, \text{SO}_3$). Therefore two equivalents of protosulphate of iron represent one equivalent of chlorine, since one equivalent of chlorine is required to convert two equivalents of protosulphate of iron into one equivalent of persulphate of that base.

12. The experiment is performed as follows:—Pulverize 278 grains (two equivalents) of crystallized protosulphate of iron ($2 \text{Fe O, SO}_3, 7 \text{HO}$), and mix them in a small flask with 44 grains of the manganese under examination, and previously reduced into very fine powder. These 44 grains represent one equivalent of pure peroxyde of manganese

(Mn O_2), and would, therefore, if pure, peroxydize exactly the two equivalents, or 278 grains of protosulphate of iron. About three fluid ounces of strong hydrochloric acid should now be poured upon the mixture in the flask, which flask must be immediately closed with a perforated cork, provided with a funnel tube drawn into a point internally, in order that the vapour may escape, and the whole is then rapidly boiled. The chlorine disengaged by the manganese, is immediately absorbed by the protosulphate of iron. We just said that 44 grains of peroxyde of manganese would, if pure, exactly peroxydize the 278 grains of protosulphate of iron, but as the manganese of commerce is never pure, it is evident that the 44 grains of the sample employed will prove insufficient to peroxydize the iron, and hence the necessity of ascertaining the amount of protosulphate which could not be peroxydized, and which remains in the acid solution. This may be done by means of a chlorate of potash test-liquor, as follows :—

13. Since one equivalent (124 grains) of chlorate of potash (KO, Cl O_5) produce, under the influence of boiling hydrochloric acid, six equivalents of chlorine, as shown by the equation



it follows that 20.66 grains of chlorate of potash would be sufficient to peroxydize 278 grains (two equivalents) of protosulphate of iron, and would therefore represent 36 grains (one equivalent) of chlorine, or 44 grains (one equivalent) of peroxyde of manganese.

14. The chlorate of potash test-liquor, therefore, is prepared by dissolving 20.66 grains of chlorate of potash in 1000 grains-measure of water. The solution is then poured carefully, drop by drop, from a glass-alkalimeter through the funnel tube into the boiling hot solution containing the salt of iron. The whole of the chlorine which is disengaged is

immediately absorbed by the protosulphate of iron, but as soon as the latter is completely peroxydized, the free chlorine which is evolved, immediately re-acts upon the colouring matter of a strip of paper stained blue by sulphate of indigo, or litmus, previously placed by the operator between the cork and the neck of the flask, and which, becoming bleached, indicates that the operation is terminated. The operator then reads off the number of measures of the chlorate of potash test-liquor which have been employed to complete the peroxydization of the protosulphate of iron.

15. Let us suppose that 50 divisions (500 grains-measure) have been employed, it is clear that half the quantity only of the protosulphate employed has been converted into persulphate, and that, consequently, the sample of manganese contained 50 per cent of impurities ; or, in other words, each measure of the test solution of chlorate of potash employed to complete the peroxydization of the protosulphate, represents one per cent. of impurity contained in the ore of manganese operated upon.

16. The air should be excluded from the flask during the peroxydization of the protosulphate of iron, else the oxygen of the air acting upon the salt of iron would peroxydize a portion of it, and vitiate the result. Instead of protosulphate of iron, protochloride of iron may be used. For which purpose, 56 grains (two equivalents) of pianoforte wire should be put into a matrass, or flask, as above mentioned, and about four fluid ounces of pure concentrated hydrochloric acid poured upon them. The flask being closed, as directed in the preceding process, with a cork provided with a funnel tube drawn to a point at the lower end, a gentle heat is then applied to promote the solution of the iron. When all the metal has dissolved, the operator introduces 44 grains of the peroxyde of manganese under examination, previously reduced into fine powder, and kept in readiness, weighed, and folded up in a piece of paper ; the flask is immediately closed with its cork, the liquor is slightly agitated, and then brought

to the boiling point. The chlorine disengaged by the manganese is completely absorbed by the protochloride of iron, the excess of which is determined by the chlorate of potash test-liquor, exactly in the same manner as just above explained.

17. By the methods which we have described, the proportion of chlorine which a sample of manganese can evolve may be ascertained, it is true, but this alone is far from constituting the commercial value of the article as a source of chlorine ; it is not less important to determine the proportions of the other substances, such as peroxyde of iron, earthy carbonates, &c., which may be contained in the sample, and which unprofitably consume a certain quantity of hydrochloric acid without evolving chlorine, and merely producing chlorides of iron, of calcium, of barium, &c. Hence the necessity of estimating not only the quantity of chlorine which a given weight of peroxyde of manganese can yield, but likewise the proportion of hydrochloric acid which is uselessly saturated by the foreign substances contained in the ore. For this purpose, the following method, which was first recommended by Gay Lussac, may be resorted to.

18. One equivalent, or 44 grains of the peroxyde of manganese under examination, are treated by an excess of hydrochloric acid, for example, by 500 grains-measure of acid of specific 1.093, which quantity contains, according to Dr. Ure, 100 grains of real acid. The amount of chlorine corresponding to that of the pure manganese in the sample is then determined, as mentioned before, by means of protosulphate or protochloride of iron.

19. Since 44 grains (one equivalent) of pure peroxyde of manganese require 74 grains (two equivalents) of pure hydrochloric acid to evolve 36 grains (one equivalent) of chlorine, if we saturate the excess of hydrochloric acid employed, by means of a solution of carbonate of soda, (see *Acidimetry*,) and thus determine the quantity of free acid, the difference will at once show what quantity of acid has

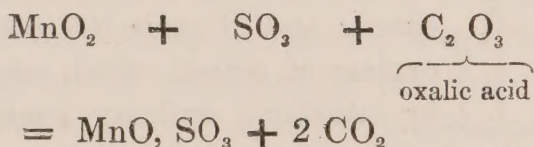
been consumed both by the peroxyde of manganese, and by the foreign substances conjointly ; but if we now subtract from that number the quantity consumed by the manganese, which will have been ascertained in the first part of the experiment, the remainder will of course represent the proportion which has been uselessly consumed by the impurities.

20. Let us suppose, for example, that in order to saturate the excess of free acid left after the determination of the chlorine evolved by the manganese, it is found that 140 alkalimetical measures of the test-solution of carbonate of soda have been required.—Since 100 alkalimetical measures of carbonate of soda saturated 97 grains of pure hydrochloric acid, the 140 measures employed represent therefore 51.86 grains of acid left in excess, and in a free state, which being deducted from the 100 grains, (contained in the 500 grains-measure of acid of specific gravity 1.093 employed,) leave 48.20 grains as the proportion of real acid consumed by the manganese and impurities of the sample. Let us suppose now, that the 44 grains of manganese operated upon have been found in the first part of the experiment to contain only 22 grains (or 50 per cent.) of peroxyde of manganese, as before mentioned, these will, therefore, have consumed 37 grains of hydrochloric acid, which being deducted from the 48.20 grains (the joint quantity consumed by the manganese and impurities) leave 11.20 grains as the proportion of pure hydrochloric acid wasted, or uselessly taken up by the impurities alone, and therefore, the 44 grains of manganese operated upon consisted of—

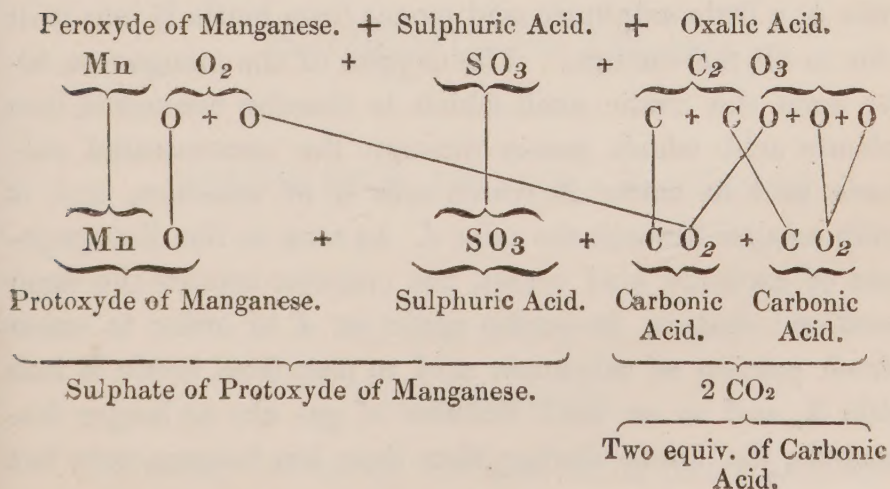
Pure peroxyde of manganese evolving	}	22.00 = 50.00
one equiv. (36 gr.) of chlorine . . .		
Impurities unprofitably consuming	}	6.65 = 15.11
hydrochloric acid		
Other substances		15.35 = 34.89
		44.00 100.00

21. The amount of *water* contained in the sample may be separately estimated by exposing a given weight of it (100 grains for example) in a capsule at a temperature of about 215° Fahr., until they cease to lose weight. The loss indicates of course the per centage of water.

22. *Another method* of determining the commercial value of peroxyde of manganese is that of Drs. Fresenius and Will. This method rests upon the fact, that when peroxyde of manganese is treated by oxalic acid, or oxalate of potash, in presence of an excess of sulphuric acid, the result is sulphate of protoxyde of manganese, carbonic acid being at the same time evolved, as shown by the following equation :—

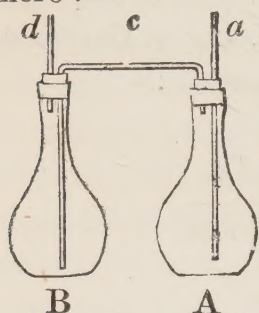


23. That is to say, one equivalent of peroxyde of manganese, under the influence of sulphuric acid, parts with one equivalent of oxygen, which is transposed to the three equivalents of oxygen of the oxalic acid, thus forming two equivalents of carbonic acid. The above equation may be dissected as follows :—



One equivalent of peroxyde of manganese (44 grains) is therefore capable of producing in this manner two equivalents of carbonic acid = also 44 ($\text{CO}_2 = 22 \times 2 = 44$), which escape in the state of gas, so that the loss of weight resulting from the escape of the carbonic acid is equal to the weight of the peroxyde of manganese.

24. The apparatus employed by Drs. Fresenius and Will is the same as that which they have contrived for alkali-metrical and acidimetrical operations, and which we reproduce here :—



Into bottle A, 44 grains (one equivalent) of the manganese to be examined, previously well pulverized and levigated, are introduced; and likewise 100 grains of neutral oxalate of potash, which may be prepared by saturating ordinary oxalate of potash with carbonate of potash, and evaporating to crystallization. The neutral oxalate of potash should be pulverized, and the bottle B is then filled with sulphuric acid to about one-third of its capacity. The flasks A and B are then corked air-tight, and thus connected into one apparatus, the whole is then accurately weighed. The opening *a* of the tube of bottle A being closed by a small lump of wax, the operator sucks a little air at *d*, a vacuum being thus made in bottle A, a little sulphuric acid passes from bottle B into it in order to fill the vacuum. The oxygen of the manganese reacts upon the oxalic acid, which is thereby converted into carbonic acid which passes through the concentrated sulphuric acid in bottle B, which robs it of moisture, and it finally escapes through the tube *d*. As soon as the disengagement of carbonic acid ceases, the operator repeats the same operation; that is, he sucks again at *d* in order to cause a fresh portion of sulphuric acid to pass from bottle B into bottle A, and so on until bubbles of gas are no longer disengaged; the bottle during that time has become very hot

from the contact of the concentrated sulphuric acid with the water.

25. When a fresh portion of sulphuric acid at last fails in producing a disengagement of carbonic acid, the operator removes the little wax stopper, and again sucks the air at *d* in order to expel the carbonic acid from the apparatus, and replace it by common air. The suction must be continued as long as a taste of carbonic acid is perceptible. When the apparatus has become cold, it is to be weighed again; the loss of weight indicates the amount of pure peroxyde of manganese in the sample; each grain of carbonic acid evolved represents one grain of peroxyde of manganese.

26. In this mode of treatment it is of course absolutely necessary to treat the manganese ore with dilute nitric acid, as mentioned at the beginning of this article, in order to remove any carbonate which might be present.

MANNHEIM GOLD.—See *Brass*.

MARLS.—See *Lime*.

MASSICOT.—See *Litharge*.

MERCURIUS DULCIS.—See *Calomel*.

M E R C U R Y.

QUICKSILVER.

1. Mercury is a metal which, at the ordinary temperature, is fluid, of a silver white colour, with a slight tinge of blue,

very bright, tasteless, inodorous; specific gravity 13.568. It boils at about 600° Fahr., and may be distilled. Mercury is not very perceptibly acted upon by exposure to the air, but when adulterated by other metals, especially by tin, it becomes converted into a black powder, which yields oxygen when heated, the mercury being at the same time revived.

2. Mercury, as it is met with in commerce, is generally very pure, yet it is often adulterated with *lead*, *tin*, *bismuth*; sometimes also it contains *copper*. These impurities, however, are easily detected, because pure mercury does not wet glass, china, or other similar surfaces, and therefore when thrown into a porcelain dish or saucer, the globules are spherical, and remain so when moved about; whilst if adulterated with any of the above mentioned metals, it wets the glazed surface, and the globules, instead of remaining spherical, adhere to the surface, or are dragged in oval or irregular masses, leaving a sort of *tail*, which indicates at once the presence of impurities in solution. Pure mercury, when poured into a glass tube closed at one end, presents a convex surface, whilst if it contains other metals in solution, the surface is either plane or concave. Mercury, which contains $\frac{1}{4000}$ of lead, has a plane surface when poured into a glass tube, and therefore this amalgam is often employed for thermometers and other instruments. The objection to the use of such an amalgam in thermometrical tubes of a small bore is, that the column of mercury moves with some difficulty, on account of its adhesion to the glass; and moreover, it often becomes divided into two or more portions, which remain hanging in the capillary tube, interfering with the correctness of the instrument; it is sometimes troublesome, or even impossible, to reunite these portions of the mercury in one unbroken column, even by imparting a rapid centrifugal motion to the instrument.

3. When the surface of mercury soon becomes dull or tarnished, or covered with a film, or with a black powder, or

does not readily separate into round, brilliant globules, it is not pure.

4. Mercury being completely volatilized by heat, distillation offers an easy means of separating it from the other metals with which it may be mixed. The distillation may be effected in a bent iron-tube, or in an iron-retort provided with a bent iron-tube connected with a receiver, or in strong glass-retorts, as used in the usual way for liquids ; the impurities remain in the retort.

5. When mercury is distilled in a glass-retort, it is advisable to mix with it about one-third or one-fourth of its weight of iron-filings, and the neck of the retort should be connected with a receiver half full of water ; the opening or extremity of the retort should be adjusted so as to reach the surface of the water without plunging into it. If the neck of the retort is too short, it may be lengthened by a glass-tube or by a roll of paper.

6. M. Millon remarked, that the presence of certain metals, such as lead and tin, impede considerably the distilling of mercury, which is, on the contrary, accelerated by other metals, such as platinum. M. Barreswill has shown that this effect is due, in the first case, to a pellicle of oxyde from the oxydisable metals, which, covering the surface of the mercury, prevents its volatilization. A layer of oil, or of resin, acts in the same way.

7. When the mercury contains arsenic, or zinc, a portion of the zinc and the whole of the arsenic distil over with the mercury. In such a case, the mercury should be treated by dilute nitric acid, and the whole should be well shaken. The arsenic and zinc, and, in fact, all the metals which it contains may be thus eliminated, except tin ; in the latter case, hydrochloric acid may be used, and a gentle heat applied.

8. The presence of arsenic is detected in the above solution by passing a stream of sulphuretted hydrogen through it, collecting the precipitated sulphuret on a filter, and

examining it before the blow-pipe, with soda upon charcoal. An odour of garlic is indicative of the presence of arsenic ; or the precipitate may be examined in a glass tube, as described in the article on Blanc Mange.

M I L K .

1. Milk is a peculiar and well-known liquid, secreted by mammiferous animals for the nourishment of their young. The milk from the cow alone is the object of this article.

2. The quality of the milk sold in London and other large towns is always extremely variable. The frauds practised in that very important alimentary substance are of two kinds : frauds by addition, and frauds by subtraction. The result of the practical working of these two rules, applied to milk, is always a *loss* to the consumer,—subtraction of cream, addition of water, of yellow colouring matter, of flour, of emulsions of hempseed, &c. ; to give the milk a creamy or rich appearance which it does not really possess by itself.

2. Plaster and chalk, and other substances of that kind, it is said, are sometimes added to milk ; but that fraud, it would appear, is much less frequent than is generally supposed, doubtless, on account of the facility with which such substances are detected, since on leaving the vessel containing the milk at rest for a short time, they settle down as a sediment.

3. Genuine milk is of a white, or slightly yellowish-white colour, opaque, heavier than water, its mean density being 1.0324, of a sweet and peculiar taste ; its composition is here given :—

Milk	Cream	Butter.....	{	Solid fat.....	1	Stearine.
				Liquid fat	2	Butyrine.
					3	Oleine.
		Butter-milk	{	Caseum.		
				Serum or whey.		
	Skim milk	Matter coagu- lable	{	By rennet	4	Caseum.
				By acetic acid	5	Zeiger or serai.
		.....		Saccharine matter ...	6	Sugar of milk.
				Azotized matter	7	Osmazome.
		Whey or serum.	{	Soluble in alcohol....	8	Alkaline and earthy lacta- tes and phos- phates.
				Soluble in water, not in alcohol.....	9	Alkaline sul- phates and phosphates.
				Insoluble in water ..	10	Earthy and ferruginous phosphates.
		Salts.....				

4. Milk is therefore essentially a mixture of cream and of skim-milk. The cream, which consists of butter and caseum, is lighter than the skimmed milk, which consists of caseum, and sugar, sugar of milk, and of various salts.

5. Berzelius gave the following analysis of skimmed milk :—

Water	928.75
Caseum and butter	26.00
Sugar of milk	35.00
Alcoholic extract and lactates	6.00
Chloride of potassium	1.70
Phosphate of alkali	0.25
Phosphate of lime, lime com- bined with the caseum, mag- nesia, and traces of iron	2.30
	1000.00

6. In order to detect the presence of the various substances which may have been added to dissimulate the addition of water, proceed as follows :—

7. The milk should first be coagulated, by boiling it with a little acetic acid, and it is then filtered. The filtered serum is allowed to cool, and when quite cold it is tested with a few drops of a solution of iodine. If this produces a blue colour, it is a sign that *starch*, *flour*, or a *decoction of bran*, of *barley*, or *rice*, or some other *amylaceous* substance has been added.

8. When *gum arabic* or *dextrine* has been mixed with milk, its presence may be detected by pouring alcohol in the serum or liquor filtered from the coagulum produced by acetic acid, because a white, opaque precipitate is then formed, very different from the light, bluish and diaphanous flakes which alcohol produces in pure milk, and which are besides much less abundant. The precipitate produced may be separated by filtering, and identified as gum or dextrine by drying.

9. The addition of gum arabic to milk seems hardly probable, at least practically, since it scarcely affects the density of the milk. According to M. Quevenne, an addition of not less than 1582 grains per quart of water are required to bring it to a density of 1.030, which is about the density of milk. The fraud would therefore be unprofitable, and consequently is not very likely to take place.

10. *Gum tragacanth* is sometimes employed in the state of mucilage to augment the volume of the cream in ordinary milk, or to simulate its presence on skim milk. Gum tragacanth may be detected by boiling the milk and leaving it at rest for some hours, a gelatinous, translucent deposit is then formed, which being washed with a small quantity of water, and tested by a few drops of solution of iodine, produces a blue colour, because gum tragacanth contains starch.

11. According to MM. Raspail and Barruel, two per cent. of sugar added to milk, are sufficient to impart a decided

sugary flavour to it, and even one per cent. is sufficient to impart an unusual degree of sweetness. Sugar, therefore, can hardly be employed to augment the density of milk. However this may be, its presence is easily detected by coagulating the milk, filtering, and mixing a little yeast with the filtrate. If the whole be then exposed to a temperature of between 70° and 80° Fahr., an abundant and rapid disengagement of gas will take place in the course of two or three hours. Fermentation in that case, is a sure sign of the presence of sugar, for pure milk cannot ferment, at least in so short a time, and the fermentation is never brisk. But the smallest proportion of sugar (either grape or cane sugar) very speedily gives rise to a tumultuous fermentation.

12. The experiments of M. Quevenne, seem to prove that the emulsion of hempseed and of almonds cannot be employed for adulterating milk, as is generally supposed, for hempseed communicates to the milk a very unpleasant flavour, and almonds very speedily coagulate it.

13. Milk is sometimes kept in zinc-pans for the purpose of augmenting the yield of cream. It should be known that lactic acid, which is formed in that case, and which exists in the free state even in new milk, might decompose a little of the carbonate, or saturate a little of the oxyde of that metal, and render the milk unwholesome and possibly poisonous. The presence of zinc is detected by coagulating the milk with nitric acid, filtering, supersaturating with ammonia, and filtering again if necessary; if, on pouring hydrosulphuret of ammonia in the clear filtrate, a white precipitate is formed, it is sulphuret of zinc.

14. In order to prevent milk from turning sour, or from coagulating, a little carbonate of soda may be, and is sometimes added; milk may thus be kept for eight or ten days. This addition is harmless, provided the quantity added be not too great. According to D'Arcet, $\frac{1}{2000}$ part of bicarbonate

of soda is sufficient for the purpose. The presence of carbonate of soda in milk may always be detected by adding to the milk its own weight of strong alcohol, by which the caseum is separated ; both the caseum on the filter, and the liquor filtered therefrom, being tested with reddened litmus paper, or turmeric paper, an alkaline reaction will be observed, if carbonate of soda is present, that is to say, the reddened litmus paper will be rendered blue, and the turmeric paper brown. Moreover, if the filtrate be evaporated to dryness, and an acid poured upon the residuum, a perceptible effervescence will be observed, which is due to a disengagement of carbonic acid gas, from the decomposition of the carbonate of soda by the acid employed. Pure milk treated in the same manner, yields a caseum and serum which is neutral to test papers, or which has a slightly acid reaction, and the dry residue of the evaporated serum never effervesces when treated by an acid.

15. As to the adulteration of milk by the addition of the cerebral matter of various animals, accounts of which were published by newspapers some time ago, it would appear from the experiments which were performed at that time by the "Conseil de Salubrité," that no such admixture could be detected in any of the considerable number of samples of milk which were then submitted to examination ; the results of the investigations made by the eminent chemists of the Conseil, have proved that, were this disgustingly horrible fraud ever practised, it could be immediately detected by the microscope.

16. Considering, that of all the constituents of milk, caseum is that, the normal quantity of which is less influenced by the kind of food given to the animal, than any other, it is possible, by coagulating hot milk with a few drops of acetic acid, and collecting the caseum or cheese so produced, draining, and pressing it well, to estimate very approximatively from its weight, the relative purity of the milk. Pure milk yields 10 per cent. of curds or cheese ; five per cent. only, if

the milk has been mixed with its own weight of water, (half milk, half water) ; 3.33 when it has been diluted with twice its weight of water, and so on in proportion.

17. According to M. Barruel, the caseum of milk which has been sophisticated with emulsions, leaves a greasy stain on paper, and if it be pressed, a little oil oozes out.

18. The most frequent, and, one might say, the unexceptional adulteration of the milk sold in towns, consists in an addition of water. Pure milk having a mean density of about 1.031, or 1.030, the addition of water may, to a certain extent, be detected by means of the specific gravity bottle, or hydrometer. According to M. Lassaigne, the specific gravity of cow's milk at 50° Fahr. is 1.031, and it would appear that an addition of one-quarter or one-third of the volume of such milk is necessary to lower its gravity to the extent of 0.017 or 0.018. The results of M. Lassaigne's experiments are as follows :—

	Specific gravity.
Pure milk at 50° Fahr.	1.031
73 parts of milk with 25 parts of water =	1.021
66 parts of milk with 33 parts of water	1.020

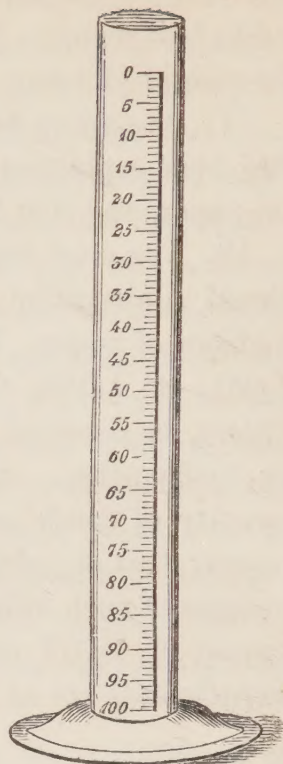
The specific gravity, therefore, proves only that the density of milk should never be below 1.031, or 1.030, but can give no indication respecting the quantity added up to one quarter.

19. As cream separates completely from milk after several hours' standing, the measurement of the quantity of cream given by it, might, therefore, be taken as a criterion of the quality of the milk. For this purpose, an instrument called a "*galactometer*" is sold by philosophical instrument makers, by means of which the quantity of cream contained in milk can be approximately estimated, the proportion of which, of course, represents the relative value of milk.

20. The galactometer is simply a large tube divided into 100 equal parts. The milk to be examined is poured into the tube up to 0, and the whole is left in a clean and cool place for 10 or 12 hours in summer, and from 15 to 16 in winter. At the end of that time, the whole of the cream will have risen up, and the quantity per cent. of the cream contained in the milk is then determined by the number of degrees occupied by the cream.

21. The thickness or stratum of cream in pure milk is generally from 8 to $8\frac{1}{5}$. If the milk submitted to experiment has been mixed, for example, with one-third of water, the quantity of cream produced, will be reduced to $6\frac{1}{2}$; if mixed with half water, 5, and if adulterated with two-thirds of its volume, the cream is only 3 per cent. of the bulk. Such an instrument may evidently prove useful to the consumer, but more especially so to the farmer, who may then ascertain the relative influence of various kinds of food on the quality of the milk given by his cattle, and consequently the relative value of his milch-cows.

22. With respect to the food given to cattle, the experiments of MM. Boussingault and Lebel have established the fact, that the nature of it has not a great influence upon the quantity and chemical constitution of milk, provided the different kinds of food be given in quantities containing equivalent proportions of nutritious principles. We should say, also, that the indications given by the galactometer are not very accurate, since the volume of the cream in milk varies with the temperature to which it may have been exposed. The most favourable temperature, that which gives the maximum of cream, is 46° or 47° Fahr. But,



according to the experiments of M. Quevenne, ("Annales d'Hygiène publique et de Médecine légale,") it would seem that at a temperature of 53° to 68° Fahr., the volume of the cream from a same kind of milk remains even.

23. Considering that the principal fraud committed in milk is the addition of water, and the abstraction of the cream ;

That pure milk always consists of from 90 to 93 per cent. of water ;

That any plaster or chalk, &c., which may have been added, may be readily separated by subsidence ;

24. The best method consists, perhaps, in allowing a given quantity of the suspected milk to remain undisturbed in a precipitating glass for about one hour, and decanting. No deposit should be formed.

25. Of the milk so decanted, one thousand grains-measure should be evaporated to dryness at a gentle heat, and when it has ceased to lose weight, the residuum left should not be less than 70 grains.

26. Or another weighed portion of the decanted milk, should be warmed with acetic acid, and the curds being carefully separated and squeezed, the scum so produced being carefully evaporated at a steam-heat, should yield from 4 to 5 per cent. of dry residuum.

27. Milk which has been mixed with water has a bluish hue, especially observable on the sides round the dish which contains it.

28. According to Pfaff and Swartz, 1000 grains of pure milk yield 3.044 of ashes, consisting of,

Phosphate of lime		1.805
„ Magnesia		0.170
„ Iron		0.032
„ Soda		0.225
Chloride of calcium		0.115
Soda		0.697
		3.044

29. The "*Comptes Rendus*" and "*Chemical Gazette*" published the following article, by Professor Poggiale, "On the Estimation of the Sugar of Milk, and Determination of the Richness of Milk."

"As none of the processes hitherto known furnish a quick and accurate indication of the richness of milk, I imagined that if we could determine without the balance, by the method of volumes, one of its constituent elements, the problem would be solved. I believe I have succeeded in attaining this result by ascertaining the proportion of the sugar of milk. Several samples of pure milk have been submitted to chemical analysis.

The following is the mean of ten analyses:—

Water		862.8
Butter		43.8
Sugar of milk		52.7
Caseine		38.0
Salts		2.7
		1000.0

"Thus, according to my experiment, 1000 grammes of milk contain 52.7 grammes* of sugar; M. Boussingault found, in a series of observations, a mean of 50 grammes, a difference which is undoubtedly owing to the processes followed for its determination. The quantity of sugar contained in milk is considerable, and, moreover, presents but slight variations. The process which I propose is the application of that of M. Barreswil to the estimation of the sugar of milk, which, like glucose, reduces the salts of copper; and the proportion of salt of copper decomposed will afford the amount of sugar of milk.

"*Preparation of the test-liquor.*—This is prepared by adding to a solution of sulphate of copper bitartrate of potash, and dissolving the precipitate which is formed in caustic

* The gramme weighs 15.4330 grains.

potash. The strength of the alkaline solution is then determined with great care, from the quantity of sugar employed to decolourize a known volume of the liquid. It is important to observe that milk-sugar, and not cane-sugar, must be employed in this operation. I made several experiments in order to avoid the determination of the strength of the solution of binocide of copper, which is decidedly the longest and most delicate experiment. The following proportions constantly furnished a liquid, 20 cubic centimetres of which correspond to 0.200, or 2 decigrammes, of whey :—

Crystallized sulphate of copper . . .	10 grammes.
Crystallized bitartrate of potash . . .	10 „
Caustic potash	30 „
Distilled water	200 „

“The filtered liquid is perfectly clear, and of an intense blue colour.

“*Preparation of the Whey.*—To determine the amount of sugar of milk, it is indispensable to separate the fatty matter and the caseine by coagulation. This is easily effected by placing 50 or 60 grammes of the milk in a small flask, adding to it a few drops of acetic acid, and then raising the temperature to between 104° and 122°. A transparent liquid is obtained on filtration. According to my experiments, 1,000 grammes of milk yield 923 grammes of whey, which gives for 1,000 grammes of whey about 57 grammes of sugar.

“*Examination of the Whey.*—20 cubic centimetres of the test-liquor are introduced by means of a pipette into a small flask, which should be preferred to a porcelain capsule, as it allows of the liquid being seen from top to bottom, and of observing with the greatest ease the moment the decolourization is complete. The liquid is then boiled. On the other hand, a burette, each division of which is equal to a fifth of a cubic centimetre, is filled with the whey, and

poured drop by drop into the liquid, agitating the latter continually, and heating it after each addition of whey. This is continued until the blue tint has entirely disappeared. At first a yellow precipitate of hydrated protoxyde of copper is formed, which, however, soon turns red and sinks to the bottom of the flask. When the operation is terminated, the quantity of whey employed is read off the burette, and the weight of sugar contained in 1,000 grammes of whey determined by the rule of three.

“I admitted above that 1,000 grammes of whey contain 57 grammes of sugar; we must, however, not be particular about a few grammes more or less. The most usual adulteration, the addition of water, is easily detected by estimating the sugar. It is, however, possible that the cream might be removed without any addition of water, or with the addition of cane-sugar or sugar of milk. In this case I determine by a simple and quick process the quantity of fatty matter by adding acetic acid to the milk, boiling, and agitating it after cooling with ether, which removes the butter. The ethereal solution is decanted and evaporated. It is frequently advisable to repeat the examination of the whey, which, as all the arrangements are made and the strength is nearly known, does not occupy more than one or two minutes.”

MINIUM.—See *Red Lead*.

MORTARS (HYDRAULIC).—See *Lime*.

MUNJEET.—See *Madder*.

MURIATE OF AMMONIA.—See *Sal Ammoniac*.

MURIATE OF BARYTA.—See *Chloride of Barium*.

MURIATE OF SODA.—See *Chloride of Sodium*.

MURIATIC ACID.—See *Hydrochloric Acid*.

MUSK.

1. Musk is a substance of a peculiar and well-known odour, secreted in a bag by the male musk deer (*moschus moschiferus*, a species of chevrotain belonging to the moschidæ or musk tribe,) closely resembling the deer in its general form and appearance, inhabiting the mountainous Kirgesian and Sangorian steppes of the Altai, on the river Irtysh, extending eastwards as far as the river Jenesi and lake Baikal. It exists also in Mongolia, Thibet, and Butan, as far as Tonquin, and generally in the mountains of Eastern Asia, ranging between 30° and 60° of latitude. The musk is found, as above said, in a bag under the belly of the male animal, and consists of several superposed membranes externally covered by the skin and hair. Musk, as found in commerce, is solid and granular, of a peculiar, persisting, and well known odour.

2. “In trade, two distinct species of musk are known, which we shall distinguish as Musk *a*, comprising the Chinese Tonquin, Thibetian, or Oriental musk, and Musk *b*, which includes the Siberian, Cabardinian, or Russian musk. These varieties, which for the sake of brevity we shall term, the one Russian and the other Chinese, differ materially both in the external appearance of the bag and the colour of the hair which covers it, as well as in their chemical and physical properties, and different effects on the human constitution.

3. “It is generally supposed that these differences depend

chiefly on the difference in climate which the animals inhabit, and partly is to be attributed to the difference in food which such variations in temperature occasion. By some, however, it has been premised, that to a difference in species may be attributed the differences of the drug. Dr. Goebel is of opinion rather that these different properties of Chinese musk, as compared with the Russian, should be mainly, if not entirely, attributed to the difference of treatment which they undergo in China, and he considers that the Chinese musk is the natural product after it has been subjected to the ingenious adulterations of the Chinese. The following are the reasons for this supposition :—

4. “Irbis, a small town of Asiatic Russia, known chiefly for the considerable barter trade which is there carried on in the month of February between Russian, Bucharian, Chiwinzian tribes, with Persian, Armenian, and other Asiatic nations, is also the main market for the Russian, or, as it is there termed, Siberian musk. It is less frequently taken to the market of Nischnei Novgorod. The Asiatics bring to Irbis the musk bags enveloped in the original greyish white skin, as cut from the belly of the musk deer, and sell them, either to the Russians, who carry them to St. Petersburg and Moscow; or, in the event of their not being able to drive a profitable trade with these merchants, they dispose of them to other Russian traders, who carry on a commerce with China by Kjachta.

5. “The Russian merchants, who bring the musk from Irbis to St. Petersburg and Moscow, trade only between these towns and Irbis, but those who carry it to Kjachta, trade only between the said town of Kjachta and Irbis.

6. “In case the price of musk is remunerating at St. Petersburg and Moscow, then the Russians who trade there purchase the musk bags, and pay good prices; on the other hand, when it is low in these places, the Asiatic finds his customer in the trader to Kjachta. Sometimes it is brought to St. Petersburg in large and sometimes in small parcels,

occasionally packed in chests, whilst at others it is loosely carried in bags of leather or felt, and sold generally to druggists.

“The Irbit musk is invariably enveloped in the greyish-white belly-skin, and the bags are separated when it is sent to St. Petersburg, this being done only after it has been sold to the St. Petersburg trader; for a bag accompanied with the skin rarely arrives at St. Petersburg. If, however, the musk is sold to those traders who proceed with their wares for the Chinese market *viâ* Kjachta, this appendage is indispensable, because the Chinese, who exchange tea for it, would not purchase it except in its original state. From Kjachta it is taken into the interior of China, and the process of adulteration it there undergoes is entirely unknown; but it is a fact, the authenticity of which is indisputable, *that no Russian musk bag is ever re-imported from China viâ Kjachta*, the only trading mart between Russia and China; and further, *that not a single bag of Chinese musk ever arrives in Russia viâ Kjachta*.

“The Russian musk, when exported from Russia, is always genuine and unadulterated; the bags never being opened, are consequently never sewn, or closed in any artificial manner. Sometimes it is obtained so fresh that moisture may be expressed therefrom by cutting through the fleshy side of the bag. The interior mass is frequently of a soft and pappy consistence; externally, however, the bags are perfectly dry.

“That which is termed Tonquin or Chinese musk comes into the market only through the London trade, and by no other channel, although much of this is consumed in Russia, no bag being ever received *viâ* Kjachta, but always imported directly from London. These Chinese musk-bags are found, on examination, invariably to have been opened, and more or less carefully glued together; sometimes, indeed, the stitches by which they are held together are visible.

“We have the assurance of Mr. Dyrssen, that during the

many years he has been engaged in trade, although he has frequently received quantities of from 100 to 200 ounces at a time from London, yet in no case whatever has he met with a bag which had not been opened, and closed with more or less ingenuity. He believes also that he has recognized the Siberian bags, although somewhat modified. Whether the Chinese musk, in its peculiar package, is received in that state at the English factory at Canton, as is most probably the case, or whether it is there made up, we are not in a position to state. Dr. Fr. Goebel relates, that in the year 1825 he received, through Jobst and Klein, of Stuttgard, a Chinese musk-bag, to which was adherent a portion of the skin attached to the belly and the genitals : this Dr. Goebel opened, in the presence of the eminent naturalist Oken, and it was represented by Ratzeburg and Brandt, in their description of officinal animals ; and of which Oken gave an account in his *Isis*, and which appeared also in *Kastner's Archives*. This bag, which the Doctor has still in his possession, was of the same form, and, in colour and size of the hair, precisely similar to the Russian musk-bag, with which he had an opportunity of comparing it whilst on a visit to Russia. The contents, however, of this musk-bag differed materially, in their chemical and physical properties, from those of the pure Siberian musk-bag. Buchner, in his *Repertory*, has given a description of a musk-bag, which coincides with that in Dr. Goebel's possession. The weight of grain-musk from this bag was 225 grains, and cost 30 thaler conv. munze—about £4. 10s.

“If we take a Chinese musk-bag, with its partially bald surface and yellowish-brown hair here and there cut off, and soften the same by digestion in warm water, we perceive pretty plainly that it has been subjected to artificial changes. The external skin is tender, and may be easily torn, as if it had been destroyed by partial decomposition ; the hairs have either fallen off or been removed by force : indeed, the longer hairs clearly appear to have been cut off.

“Why do not the musk-bags from China arrive as perfect as those from Russia? Because the contents have been removed and the bags refilled, as may be distinctly perceived by the circumstance of those hairs which surround the interior small opening which is found on the hairy side of the bag, immediately before the genital canal, being depressed; whilst in the Russian musk-bags these small hairs are found standing obliquely, and protruding in and between the secretion. It is possible, although not at all probable, that the musk deer, which abound in Thibet, Butan, &c. may possess musk-bags of a perfectly distinct character from the Russian, but no trustworthy reference or practical judge has ever witnessed the removal of such a bag from the living animal, or described it and its contents. That the grain-musk of the Chinese musk-bags which have been brought to Europe differs very much in its effects, as well as in its physical and chemical characters, from the pure Siberian, has been ascertained; and that it likewise acts with more energy on the living economy when administered internally. All the different chemical investigations of musk, for which we are indebted to Buchner, Wetzlar, Oberdoeffler, Thiemann, Blondeau and Guibourt, Geiger and Reiman, &c., taken together, afford very few hints in reply to those questions which involuntarily present themselves, in reference to the two different kinds of musk, so far as regards their chemical and mercantile relations.

“Taking, therefore, the most essential points of the preceding communication—

“1stly. That the Russian musk is always sold in perfect bags, and exported in considerable quantities to China and to London;

“2dly. That from China to Russia, no direct exportation of musk takes place;

“3dly. That the Chinese musk can only be obtained *via* London;

“4thly. That the Chinese musk-bags never arrive unopened;

“5thly. That it appears most undoubtedly that the mass has been taken out and replaced ;

“6thly. That the external appearance of the bags proves sufficiently that they have undergone artificial treatment ;

7thly. That frequently the secretion apart from the bag is imported from China, leading to the inference that a sufficient number of bags cannot be obtained wherein to put the quantity increased by adulteration ;—

“Taking all these reasons into consideration, we think the conclusion announced at the commencement cannot be avoided, namely, that the distinctly marked difference of the Chinese from the Russian musk, if not wholly, is at any rate chiefly, caused by the treatment which it undergoes in China ; and therefore that Chinese musk is the natural product after it has been modified by artificial means.

“M. Guibourt (in his *Histoire Abrégée des Drogues Simples*, tome 2^{ième}, page 744) has given the following qualitative analysis of Chinese musk, undertaken by himself and M. Blondeau :—

“1st, Water ; 2nd, Ammonia ; 3rd, Solid fat (Stearine) ; 4th, Liquid fat (Elaine) ; 5th, Cholesterine ; 6th, Acid oil, combined with ammonia ; 7th, Volatile oil ; 8—10th, Hydrochlorates of ammonia of potash and lime ; 11th, An undetermined acid, partly saturated by the preceding bases ; 12th, Gelatine ; 13th, Albumen ; 14th, Fibrine ; 15th, Carbonaceous matter, soluble in water ; 16th, Calcareous salt ; 17th, Carbonate lime ; 18th, Hairs and Sand.

“The quantity of water varies necessarily with the state of dryness of the musk : that examined by MM. Guibourt and Blondeau contained 0.46. The quantity of free ammonia, or that which is so feebly combined as to be disengaged by desiccation, varies in the same manner. The musk referred to contained 0.00325.

“The solid and liquid fats were found to be identical with that of sheep and other ruminants ; the cholesterine appeared similar to that of human biliary calculi.

“The chief exportations of musk, from the London market, are directed to Hamburg, Rotterdam, and St. Petersburg.”

2. Musk of an excellent quality is now imported from the United States free from carbonate of lime.

3. The following are the characteristics of good musk: it consists for the most part of round, oval, slightly flattened and sometimes irregular grains, the size of which varies from that of a pin's head to that of a pea, and concreted together, slightly unctuous. The colour of the grains is deep brown, almost black, with a reddish cast; when rubbed between the fingers the grains crumble, but no grittiness is felt.

4. The principal adulteration of this costly substance consists in mixing with it a portion of the *blood* of the animal, which, however, may be recognized by the larger size of the grains, which look like what in fact they are, namely clots of blood—though it should be observed that the Chinese roll up the dried blood into pellets, which imitate the grains of genuine musk very closely. If, however, these grains be heated, a fetid vapour is evolved, which is not the case with genuine musk.

5. *Asphaltum* is another substance frequently used for adulterating musk, and also a kind of black, brittle earth, sand, small pieces of lead, heavy spar, water.

Asphaltum is detected, because if a grain of the spurious musk be placed on the point of a knife, and plunged into the flame of a candle, it will fuse and inflame; whilst genuine musk does not fuse, nor does it inflame; it only becomes charred.

6. *Earthy matter, sand*, and other impurities may be easily separated, because genuine musk is soluble in sulphuric ether, and likewise in boiling water, either of which menstrua will leave the impurities in an insoluble state; in genuine musk only one-fourth of the weight is thus left undissolved.

7. Falsifications of any kind may further be detected, because all the pods or bags which have been tampered with exhibit marks of sewing or stitching, which shows that the

bags have been open for the introduction of the spurious substance. The Chinese musk-bags, however, which invariably have been opened for that purpose, are sometimes closed up again, not by stitching, but by gluing the sides together ; in which case, the fraud is much more difficult to detect by simple inspection. A genuine musk-bag, however, has two small openings, which are sometimes so contracted and narrow that they are not easily discovered, but whenever they are wanting, the pod is always spurious. The size of a genuine musk-bag varies from one to two and a half inches in diameter, and is more or less round. It is covered with stiff yellow or brownish-yellow hair, converging towards the centre. In those bags which have been obtained from old animals, the hair is less abundant, and appears as if worn out, it is also of a darker hue. This is a sign of some importance, because the goodness and value of the genuine article depends in a great measure upon its having been obtained from middle-aged animals ; that procured from either too young or too old animals being of inferior quality. The presence of a large quantity of small round grains in the interior of the bag is also a sure sign of the goodness of the musk, and when viewed through a microscope, no fibrous particles should be perceived. As we said before, the musk from Russia, or Siberia, is always pure, and sometimes so fresh, that when cut through, moisture can be squeezed out, and the mass inside is soft and pappy.

8. The chemical tests of the purity of musk are the following :—It should dissolve in boiling water, and leave only one quarter of its weight in an insoluble state, and the boiling solution should be precipitable by acids, more particularly by nitric acid, so as to become almost colourless. Solution of acetate of lead, and that of galls should likewise precipitate it ; but one of corrosive sublimate should not create the slightest precipitate or turbidness.

9. The ashes of musk, after incineration, should not be red or yellow, but grey, neither should they exceed 5 or 6 per

cent. The ashes consist of carbonate and sulphate of potash, chloride of potassium, and phosphate of lime, with traces of magnesia and of peroxyde of iron.

MYROBALANS.

1. Myrobalans are the fruits of a species of plum-tree in East India, which are occasionally brought into this country in the dried state. The dried fruit is shrivelled up like prunes, has an olive colour and shape, an unpleasant, astringent, and sweetish taste. Myrobalans are used in India, and sometimes also here, either alone or mixed with galls, for making ink.

2. An aqueous extract of this fruit was twelve or fourteen years ago brought to London, in large puncheons and hogs-heads, and after having remained for several years a perfect lumber in the warehouse at the docks, spurned by all to whom it was offered for sale, and looked upon as a perfectly useless drug, it was at last put into my hands by the importer, for the purpose of ascertaining whether any use could be made of it. I ascertained that this ill-received drug could produce a black dye and ink of surpassing depth and intensity of colour, *faster* than that obtained from the best blue galls, and of a more jetty hue. I found also that with proper management, cotton could be dyed by it of a beautiful, fast, velvet-black colour. The ink that I made from it was better in point of colour, or, at any rate, at least equal to that made from the best galls, and it resisted the action of chemical reagents incomparably better than that made in the usual manner. With alum, the extract yielded a most durable olive-green, also a brown colour of great beauty, on properly mordanted tissues. I tried also experiments with it for tanning leather, and the result has been very satisfactory; though I should remark, that the leather so tanned, retained a dingy,

olive-green colour, which for certain purposes might be objectionable. This substance, the use of which is scarcely known in this country, or which is at least but seldom employed, and never, I believe, *per se*, might, I am satisfied, be advantageously substituted for galls for most purposes, and it is much cheaper. The value of the extract may be ascertained by gelatine, exactly as for catechu.

M Y R R H.

1. Myrrh is a gum-resin met with in commerce in angular pieces, and in grains, the largest of which do not exceed the size of a filbert.

2. The best myrrh is transparent, of a reddish-brown colour, easily broken, and its fracture exhibits waving lines of a lighter colour than the mass. It has a strong, peculiar odour, and a bitter, acrid, aromatic flavour. The myrrh which comes from Abyssinia is sometimes so soft that it can be cut like tallow. Righini gives the following test for ascertaining the merits of that substance:—Pulverize the myrrh, and leave it mixed for a quarter of an hour with its own weight of sal-ammoniac, also in powder, add now fifteen times its weight of water. If the mixture dissolves completely and rapidly, the myrrh is pure.

3. The incineration of genuine myrrh should not leave more than 3.6 or 3.8 of ashes, consisting of sulphate, phosphate, and carbonate of lime, with a little carbonate and sulphate of potash, and a trace of chloride of potassium.

NICKEL—See *Kupfer-Nickel*.

NIHIL ALBUM.—See *Oxyde of Zinc*.

NITRATE OF POTASH.

SALTPETRE. NITRE.

1. *Nitrate of potash*, more generally called *saltpetre* or *nitre*, is a salt of great commercial importance, which is found in abundance on the surface of the soil, principally in East India, Egypt, America, Italy, and Spain ; it is obtained also by lixiviating certain soils called *nitre-beds*.

2. In France and in Germany, *nitre-beds* are artificially made from old plaster rubbish, old mortar, and other calcareous earth, mixed with refuse animal and vegetable matter, which putrefying in contact with the above calcareous salts, forms *nitrate of lime*. The nitrate of lime is afterwards converted into *nitrate of potash* (saltpetre), by mixture with wood-ashes and lixiviating the whole. For the particulars of this manufacture, the reader is referred to Dumas "*Chimie appliquée aux Arts*," and to Dr. Ure's Dictionary of Arts, Manufactures, and Mines.

3. The saltpetre consumed in England comes from East India, whence it is imported in the rough state, that is, in broken crystals somewhat resembling bay-salt, of a brownish or greyish colour, and more or less deliquescent.

4. Pure nitrate of potash is always an anhydrous salt, but its crystals ordinarily retain a small quantity of water of interposition, especially when the crystals are large. Its specific gravity is 1.933. It crystallizes in long striated six-sided prisms, generally terminated by diedral summits, and often contain longitudinal cavities internally. Nitrate of potash sometimes crystallizes in rhomboedrons. Pure nitre is colourless and inodorous ; its taste is at first fresh and cooling, and then somewhat pungent and bitter. It is not altered by exposure to the air, but it deliquesces in an atmosphere fully saturated with moisture.

5. According to M. Gay Lussac, the solubility of nitre in

water increases very considerably with the temperature, and in the following proportions :—

	cent.	Fahr.		
100 parts of water at	0° =	32	dissolve	13.3 of nitre.
„ „	24 =	75.2	„	38.4 „
„ „	50.7 =	123.26	„	97.7 „
„ „	79.7 =	175.56	„	169.7 „
„ „	97.7 =	207.86	„	236.0 „

6. *Sal prunella*, or *crystal mineral*, is saltpetre which has been exposed to 600° Fahr., at which temperature nitre fuses without being decomposed, and forms, in cooling, a white compact mass, which is more easily pulverized than the crystals of nitre, and which is sometimes cast into balls or cakes.

7. The impurities contained in rough saltpetre are :—

Water.

Chloride of sodium (common salt) in various proportions.

Nitrate of soda } Resulting from the re-action of
Chloride of potassium } common salt upon the nitre.

Sulphate of lime, or of alkalies.

Traces of organic matter.

8. The determination of these impurities, or the loss which results from the purification or refining of nitre is called *refraction*, and is sometimes attended with difficulties.

9. There are various methods of assaying saltpetre ; but whichever process is adopted, great attention must be paid in the taking of samples, that they may represent, when mixed, a fair average of the quality of the article.

10. One of the methods of ascertaining the value of nitre, and which, where common salt and sulphates of alkalies are the chief impurities, admits of considerable accuracy, is that which was originally proposed by Riffault, in 1789. It is based upon the property which a *cold saturated solution of nitre* possesses of dissolving certain foreign salts, namely—*chloride of sodium* (common salt), and the *sulphates of alkalies* by which the nitre under examination may be contaminated,

without sensibly dissolving any more nitre. The experiment is performed as follows :—

11. Take one pound weight of an average sample of the nitre to be analyzed, put it into a large beaker or basin, and pour upon it one pint of a *cold saturated aqueous solution* of pure nitrate of potash ; stir the whole for about ten minutes, let it digest for about a quarter of an hour, and throw the whole upon a large paper-filter. Wash the undissolved crystals on the filter with half a pint of a fresh portion of the same cold saturated solution of pure nitrate of potash, carefully collecting on the filter, by means of this second solution, all the small crystals which might adhere to the glass-beaker or basin above alluded to, and into which the sample of nitre to be analyzed was first put.

12. The nitre now on the filter must be allowed to drain well, the undissolved crystals are then dried as much as possible, first by pressure between folds of blotting or filtering paper, and afterwards by applying a moderate heat, for which purpose they should be transferred to a basin or capsule, and dried at a temperature of 212° , until the mass ceases to adhere to the glass rod with which the operator stirs it from time to time. The crystals, when dry, are then weighed again, and the loss of weight indicates the quantity of water and of foreign salts, or that of the foreign salts only ; if, before subjecting the sample to the above treatment, it has been previously exposed to a moderate heat, and then re-weighed, the loss will, of course, have indicated the proportion of water contained in the sample.

13. If the quantity of common salt is very considerable, that is, above 60 per cent., which, however, is very rare, it will be necessary to wash the undissolved crystals on the filter a third time, with half a pint more of the cold saturated solution of nitrate of potash.

14. If the nitre contains any insoluble matter, the amount of the latter is ascertained by a separate operation, which consists in simply dissolving in water a known weight of the

nitre, filtering, washing the residuum left on the filter, drying it, ascertaining its weight, and deducting it from the quantity of the nitre indicated by the former operation.

15. For commercial purposes, the above process is perhaps sufficiently correct, at least in ordinary circumstances, but the real value of nitre cannot be obtained very accurately in that manner ; for, on the one hand, the quantity of nitre which water can dissolve varying with the temperature, (see the table, p. 394, No. 5,) the test-liquor (cold saturated solution of pure nitrate of potash) may, under a same bulk, contain more or less nitrate of potash at one time than at another, or give a wrong or uncertain result from any variations of temperature even during the experiment. These sources of error, however, may be to a certain extent avoided or corrected, by making at the same time a double experiment, the one upon a given weight of the sample of nitre to be examined, the other upon a similar weight of pure nitrate of potash, and observing the loss or increase of weight which may have taken place at the end of the experiment.

16. On the other hand, the earthy matters contained in the sample, and which sometimes amount to one or two per cent., remaining mixed with the undissolved crystals, apparently augment the richness of the nitre. This source of error, however, may be obviated by removing the insoluble salts as we said, p. 395, No. 14, by a separate operation ; but there is another difficulty, arising from the soluble salts by which the rough nitre is contaminated, and which always re-act more or less, as we said at the beginning of this article, both upon the nitre of the sample, and upon the pure nitrate of potash of the test-liquor. Thus, for example, the chloride of sodium (common salt) present, by promoting the solution of a certain proportion of the nitre, diminishes apparently the amount of this latter salt, whilst the chloride of potassium thus produced determines the precipitation of a certain quantity of nitre from the test-liquor, which apparently augments the richness of the sample.

17. In general, the process which has been just described indicates from one to three per cent. more nitre than is really contained in the sample.

18. *Another method* consists in determining—

19. First, the quantity of water which a given weight of nitre loses by drying it in a sand or steam-bath, as we said before, (see p. 395, No. 12).

20. Secondly, the quantity of insoluble matter, which is done by dissolving a given weight of the sample in water, filtering, washing, and drying the insoluble residuum and weighing it.

21. Thirdly, the quantity of chlorides, and of sulphates of alkalies, by means of a solution of nitrate of silver, and of nitrate of baryta. This is done by dissolving a given weight of the nitre, filtering, and washing it, as we just said; a solution of nitrate of silver is added to the filtrate, as long as a white precipitate of chloride of silver continues to be produced. The liquor containing the precipitated chloride of silver should be moderately heated, in order to agglomerate the precipitate, which must now be collected on a small filter, washed with hot water, which, if it should pass milky through the filter, may be acidified with a little nitric acid. After washing the precipitated chloride of silver, it must be very carefully dried, scraped from the filter, and then introduced into a small counterpoised porcelain crucible; the filter itself should be burnt upon the cover of the crucible, and the ashes added to the chloride already in the crucible, which is then closed. Heat is then applied, so as to fuse the chloride of silver, and, after cooling, it is weighed. From the weight obtained, the quantity of the chloride of potassium, or of sodium in the sample is calculated; 144 of chloride of silver represent 60 of chloride of sodium, and 76 of chloride of potassium.

22. Considering, however, that the nitre under examination may be contaminated, as we said, by chloride of sodium, but more detrimentally by *nitrate of soda*, which is not only

a much cheaper salt than nitrate of potash, but one which, being deliquescent, renders the nitre containing it unfit for the manufacture of gunpowder, it is evident that these processes, by which the quantity of soda present cannot be determined, do not fulfil entirely the desideratum. This estimation, however, may be arrived at by distilling a given weight of the nitre with sulphuric acid, adding sulphate of silver, in order to convert the chloride of sodium into sulphate of soda, and filtering. The filtrate must be evaporated to perfect dryness, and the dry mass being redissolved in water, filtered, and then treated by a solution of *chloride of barium*, a white precipitate of sulphate of baryta is obtained, from which the respective quantities of potash and of soda in the sample can be calculated—

100 parts in weight of sulphate of potash give 131.8 of sulphate of baryta.

100 parts in weight of sulphate of soda give 161 of sulphate of baryta.

And, consequently, if a larger quantity of sulphate of baryta were obtained than the ratio 131.8 : 100, the excess would be due to the salt of soda, from which the quantity of soda existing in the state of nitrate of soda in the sample may be easily calculated, since 100 of sulphate of soda represent 119.3 of the nitrate of that base. It must be admitted, however, that a ready way of estimating the quantity of nitrate of soda in saltpetre is still a desideratum.

23. METHOD OF GAY LUSSAC.—Nitre may also be assayed, according to Gay Lussac, by a process similar to that of alkalimetry, for which purpose the nitre must be first converted into carbonate of potash. This is done by mixing one part in weight of the nitre with half its weight of lamp-black, and four parts of common salt are added, in order that the combustion of this mixture may be less violent, and, consequently, that there may be no loss. The above ingredients

being thoroughly incorporated, are placed in an iron ladle, and fused therein. The mass burns quickly, and becomes white or reddish. It is to be removed from the ladle, treated, and well washed with hot water. The solution thus obtained, contains carbonate of potash, and, of course, chloride of sodium, which, however, does not in the least interfere with the test. The operator now, by means of an alkalimeter, and of test-sulphuric acid, proceeds to ascertain the quantity of potash in the filtrate, exactly as if it were an assay of potash, and the details of which assay have been thoroughly explained in the article on *Alkalimetry*, to which the reader is referred.

24. Since the equivalent of nitrate of potash is 102, and contains therefore 48 of potash, and 54 of nitric acid, it is evident that each per cent. of potash indicated by the alkalimeter represents rather more than 2.12 of nitrate of potash.

25. M. GOSSART'S PROCESS.—(Comptes rendus de l'Académie des Sciences, January, 1847.) This process consists in determining what proportion of pure nitrate of potash is contained in a sample of nitre, from the quantity of the said sample which may be found requisite to transform a protosalt of iron into its persalt. This is effected by mixing a certain quantity of a solution of the nitre to be examined with sulphuric acid, and decomposing the nitre by means of a test-solution of protosulphate of iron, of a known strength, poured from an alkalimeter, drop by drop, until the mixture, being first heated, and then tested with a very dilute solution of red prussiate of potash (ferrocyanuret of potassium), it begins to give a blue precipitate, which does not disappear by boiling, and which thus indicates that the whole of the nitre being decomposed, the test-liquor of protosulphate of iron ceases to be re-acted upon, and, consequently, that the experiment is at an end. The number of divisions of the alkalimeter is then noted, and the strength of the nitre becomes thus known. This process, though very accurate, is

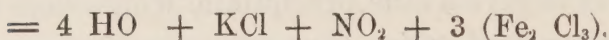
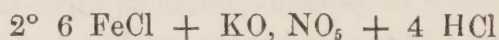
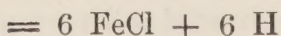
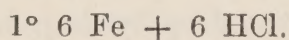
rather inconvenient, and therefore the method of M. Pelouze, which is a modification of it, is much preferable ; it is as follows :—

26. METHOD OF PELOUZE.—The experiments of M. Margueritte having shown that a dilute solution of protosulphate of iron is almost instantaneously peroxydized when a solution of permanganate of potash is poured into it at the ordinary temperature, and that the addition of the smallest quantity of the said solution of permanganate of potash imparts a pink tinge to the liquor as soon as the whole of the iron is peroxydized, M. Pelouze applied this process to the analysis of nitre, in the following manner :—

27. Instead of a solution of protosulphate of iron, one of protochloride of iron is employed. It is prepared by dissolving a certain quantity of pure iron (pianoforte-wire) in an excess of hydrochloric acid, and determining how much pure nitrate of potash is required to peroxydize it.

28. Now it was ascertained by Pelouze, that in order to transform into perchloride of iron 2 grammes (30.86 grains) of pure iron (pianoforte-wire), previously dissolved in an excess (about 1500 grains) of fuming hydrochloric acid, 1.216 grammes (18.76 grains) of pure nitrate of potash, on the average, are required.

29. The theory of this re-action is represented by the following equation :—



30. That is to say, the proportions of iron, of nitrate of potash, and of hydrochloric acid, found by Pelouze, as above said, being converted into their respective equivalents, represent—

1°. 6 equivalents of iron, and 6 equivalents of hydrochloric acid, producing 6 equivalents of protochloride of iron, and 6 equivalents of hydrogen gas, which escape.

2°. The 6 equivalents of protochloride of iron being mixed with 1 equivalent of nitrate of potash, the nitric acid of the latter (NO_3) is decomposed into deutoxyde of nitrogen gas (NO_2) which escapes, and into 3 equivalents of oxygen, which take from the hydrochloric acid 3 equivalents of hydrogen to form 3 equivalents of water, and liberate 3 equivalents of chlorine, which, uniting with the 6 equivalents of protochloride of iron, produce 3 equivalents of perchloride of iron.

31. The presence of chlorides and of sulphates does not influence the quantity of nitrate which is necessary to peroxydize the iron.

32. From this the reader may perceive, that if the nitrate of potash employed is not pure, the quantity above mentioned (1.216 gramme = 18.76 grains) of this salt will leave a portion of the 2 grammes (= 30.86 grains) of the pure iron dissolved in the hydrochloric acid in the state of protochloride of iron, corresponding to the amount of foreign substances contained in the nitre under examination; which proportion of protochloride of iron thus left may be determined by means of a test-solution of permanganate of potash, of a known strength, since a given quantity of iron decomposes an exactly corresponding quantity of permanganate of potash.

33. Permanganate of potash is prepared as follows:—

Take of peroxyde of manganese 2 parts.

„ Chlorate of potash . 1 do.

„ Caustic potash . . 3 do.

Mix the whole thoroughly, and introduce the mixture into a Hessian crucible, and keep it at a low, red heat, for about two hours. The mass, which is of a dark green colour, is

then reduced to coarse powder, mixed with three or four times its weight of water; and, after stirring the whole, nitric acid, diluted with half its weight of water, is gradually added, until the liquor assumes a fine violet colour; it is then filtered through pounded glass, or asbestos, and preserved in a glass-stoppered phial. The solution of permanganate of potash must be filtered through pulverized glass or asbestos, and not through paper or linen, because permanganate of potash is decomposed by contact with organic substances, the liquor becoming green, and then yellowish-brown. Permanganate of potash is very stable, and may be preserved for a long time without alteration, provided always that it be kept in a glass-stoppered bottle, and contact with dust or any organic matter must be carefully avoided.

Preparation of the test-solution of permanganate of potash.

34. Dissolve 25 grains of piano-forte wire in about 1,500 grains-measure of fuming hydrochloric acid. When the piano-wire will have dissolved and the disengagement of hydrogen gas has ceased, dilute the solution with about one pint and a half of common water. It is necessary thus to dilute the solution largely, and to operate in the cold, in order to guard against the excess of hydrochloric acid reacting upon the permanganate and disengaging chlorine; 1000 grains-measure of the solution of permanganate of potash, prepared as before described, being introduced into a glass-tube divided into 100 parts, in fact into an alkalimeter, it must now be gradually poured therefrom carefully, drop by drop, in the hydrochloric acid solution of iron just alluded to, stirring the liquor all the time, in order to ensure complete action, exactly as in *Alkalimetry*.

35. On adding the solution of permanganate of potash, the operator will perceive that, at first, it is decolourized as fast as it is poured in, but the rapidity of action gradually diminishes, and, at last, it imparts to the liquor a pinkish

colour, which indicates that the whole of the iron in the liquor is peroxydized. The number of divisions which have been required to obtain that result is then carefully observed, and supposing, for example, that it be found that 50 divisions of the alkalimeter have been required to peroxydize the 25 grains of piano-forte wire employed, it is evident that each division of the permanganate of potash test-liquor represents half a grain of metallic iron.

36. But whatever may be the strength of the solution of permanganate of potash, it is always easy to adjust it to any desired standard, if too weak, by concentrating it by evaporation at a gentle heat; if too strong, by diluting it with a suitable quantity of water, so that it may be brought as near as possible to such a strength that one measure of the alkalimeter may indicate half a grain of metallic iron.

37. Let us suppose, for example, that after having tested the solution of the 25 grammes of iron in hydrochloric acid, it be found that instead of 50 measures of permanganate of potash, 38 measures only have been required to peroxydize them, it is a proof that the test-solution is stronger than is advisable or convenient. The operator should therefore pour the whole of the solution of the permanganate of potash into a glass-cylinder of sufficient capacity, and accurately divided into 100 parts, until it reaches the mark corresponding to 38 measures. By filling the rest of the glass up to 60 measures with common water, it is evident that the same quantity of permanganate of potash will now be in the 50 measures as was contained before in the 38; and each degree of the alkalimeter, therefore, will now represent half grains of iron. Of course, instead of pouring the solution of permanganate of potash up to 38, the operator may, if he have a sufficient quantity of the solution, pour it into the glass-cylinder, above mentioned, up to 76, and fill up to 100 with water.

38. If the solution of permanganate of potash is too weak, it may be concentrated, as we said, by evaporation; but, in

doing this, great care must be taken that no organic matter, dust, &c. falls into it, and when adjusted, as we said, the liquor must be kept in scrupulously clean and well-stoppered bottles.

39. The test-liquor of permanganate of potash being prepared and adjusted as we said, the assay of the nitre under examination is performed as follows :—

40. Dissolve 30.8 grains of pianoforte-wire in about 1500 grains of concentrated hydrochloric acid in a flask capable of holding about half a pint; a gentle heat is then applied, the flask being kept closed with a perforated cork, through which a small tube drawn into a point is passing. The iron having entirely dissolved, the cork is withdrawn, and the operator adds to the solution 18.7 grains of the nitre under examination, either in crystals or in solution. As soon as the nitre is introduced, the flask must be rapidly closed again with the cork furnished with the tube, and the mixture is kept boiling for five or six minutes, the whole of the nitrate being then completely decomposed.

41. When the nitre is added, the liquor at first becomes brown, and thick fumes of hydrochloric acid mixed with deutoxyde of nitrogen are escaping through the orifice of the drawn-out tube, and prevent the access of the air into the flask. The boiling liquor soon turns from brown to yellow, and gradually becomes clear.

42. We said just now, that immediately after the addition of the nitre the flask must be rapidly closed, because the reaction between the protochloride of iron and the nitre must be sheltered from the contact of the air, which otherwise, by directly acting upon the deutoxyde of nitrogen, would oxydize a certain quantity of iron, and would thus render the estimate of the saltpetre apparently higher, that is richer, than it really is. The contact of the air, however, is not to be feared except just at the beginning, that is to say, at the moment when the re-action between the nitre and the iron is taking place; for, on the one hand, the stream of hydrochloric

acid, and of protoxyde of nitrogen gases which are visibly rushing from the drawn-out tube, of course, prevent the ingress of the air into the flask; and, on the other hand, it is known, that iron is peroxydized only with extreme difficulty, and very slowly by *free* exposure to the air, when contained in a strongly acid solution.

43. The liquor in the flask having become clear, as we said before, it should be poured into a large vessel capable of containing about three pints of water, and the water used for washing and rinsing the flask is added to the liquor in the three-pints vessel, until the two-thirds of its capacity are thus filled; more water must be poured in, if necessary. This done, the operator, having filled his alkalimeter with the test-solution of permanganate of potash of a known strength, as said before, proceeds to pour it gradually and carefully from the alkalimeter into the liquor contained in the large vessel, until the pinkish colour begins to appear, as we said. The pink colour indicates that the experiment is at an end. The operator then reads off the number of divisions employed, and thus ascertains the quantity of iron left in the liquor in the state of protochloride, and hence the value or per centage of the saltpetre examined.

44. Let us suppose, for example, that the test-liquor of potash employed was of the strength above mentioned, that is to say, was such that 50 divisions of the alkalimeter were required to peroxydize 25 grains of iron; that is to say, that one division of the alkalimeter represented therefore half a grain of iron; and let us suppose also, that in order to complete the peroxydizement of the iron left after treatment with the nitre as described, 13 divisions of the permanganate of potash test-liquor were required: the quantity of iron in the state of protochloride corresponding to these 13 divisions is at once known by a simple rule of proportion, for if 50 divisions of the permanganate of potash are required to peroxydize 25 grains of iron, of course 13 such divisions will have peroxydized $6\frac{1}{2}$ grains of iron.

$$50 : 25 :: 13 : x = 6.5.$$

Or, more readily, since each division of our test-liquor represents half a grain of iron, the 13 divisions employed represent, of course, 13 half-grains, or $6\frac{1}{2}$ grains.

45. The operator, therefore, subtracts 6.5 from the 30.8 which were submitted to the action of the nitre, which gives 24.3 grains as the quantity of iron peroxydized by the 18.7 of the nitre employed, and the following rule of proportion indicates therefore the quantity of pure nitrate of potash contained in the saltpetre assayed, that is to say, if 30.8 grains of iron require 18.7 grains of nitrate of potash, what quantity of nitrate of potash will 24.3 grains of iron require? Answer, 14.753 grains.

$$30.8 : 18.7 :: 24.3 : x = 14.753.$$

The 18.7 grains of nitre employed, contained therefore 14.75 grains of pure nitrate of potash; or per cent., 100 grains of the nitre examined contained 78.89 of pure nitrate, and 21.11 per cent. of impurities, consisting of earthy matter, chlorides of potassium, and of sodium, sulphates, water, &c.

46. The nitrates assayed in this manner may be in the solid state, or in solution; ordinarily, it is preferable to employ the nitrate in the solid state, but where great differences of per centage are suspected or known to exist in the samples, or in the bulk of the nitre, and their average value is required, it is better to dissolve all the samples, or a large quantity of the bulk, as follows:—

47. Dissolve 1870 grains of the saltpetre to be examined in a glass-vessel capable of holding 30,000 grains-measure of water, and the solution being effected, fill the vessel up to the 30,000 grains-measure with common water. This being done, transfer 3,000 grains-measure therefrom into a flask in which 30.8 grains of pianoforte-wire have been previously dissolved in about 15,000 grains of concentrated hydrochloric acid. The solution of the nitre should be added immediately

after the iron has disappeared in, or been dissolved by, the hydrochloric acid ; the experiment is carried on in every other respect as with nitre in the solid or crystallized state, for it is clear that the 3000 grains-measure of the solution of saltpetre above mentioned contain exactly 18.7 grains of rough saltpetre, and therefore it is exactly as if the experiment were performed with that quantity of the crystallized salt, as shown before.

48. The method of Mr. Pelouze is exceedingly accurate, to within two or three thousandths, and the analysis may be completed in about twenty minutes. But as the process is altogether grounded on the oxydizing action of nitric acid, it is evident that if other nitrates, nitrate of soda for example, were present, the results would, of course, be quite erroneous, unless an allowance were made for the proportion of the nitrate of soda which may be contained in the sample ; this latter salt containing 62.8 per cent. of nitric acid, whilst nitrate of potash contains only 52.9 per cent. of that acid.

49. It is evident that this process may be applied to the refraction of cubic or Peruvian nitre (nitrate of soda), and also to the estimation of nitric acid, or of mixtures of sulphuric and nitric acids.

50. When pure, the solution of nitrate of potash is not rendered turbid, either by solution of nitrate of silver, or by that of nitrate of baryta ; if a turbidness or a precipitate is produced, a chloride is present in the first, and a sulphate in the second case.

NITRATE OF SILVER.

LAPIS INFERNALIS. LUNAR CAUSTIC.

1. Nitrate of silver is the most important of the salts of silver, and is generally sold in shops in the shape of round sticks of the size of a quill, and of a greyish or blackish

colour, of a lighter shade internally, which, when broken, exhibit a mass of little crystals, radiating from the centre. Pure nitrate of silver is in white anhydrous crystals, in the form of six-sided tables or thin plates, or in right rhombic prisms when obtained by slow evaporation ; nitrate of silver has no odour, but it has an extremely caustic, bitter, metallic taste. Nitrate of silver is very often contaminated by *nitrate of copper*, *nitrate* or *chloride of lead*, or adulterated with *nitrate of potash* sometimes to the extent of one-third of its weight. According to MM. Henry and Guibourt, nitrate of silver is occasionally adulterated with *plumbago*, and with *peroxyde of manganese*.

2. These impurities may be detected as follows :—

3. Dissolve a portion of the salt in distilled water and test with ammonia ; if the liquor becomes blue or bluish, it is a sign of the presence of copper. This latter metal is frequently detected in commercial nitrate of silver, and is due to the silver employed for making it, and which is generally alloyed with copper, such as silver-coins or pieces of plate. Considering that nitrate of copper is easily decomposed by the heat to which the nitrate of silver is submitted in fusing it for casting into sticks, testing by ammonia, as above said, might fail in producing a blue liquor, although copper may be present. It is therefore better to add nitric acid to the solution, and then to test by ammonia, as above said. But when copper is present only in very minute proportions, the blue colour produced by ammonia may be so faint as not to be perceptible ; it is therefore better to precipitate all the silver from the solution in the state of chloride of silver, by adding hydrochloric acid until a precipitate ceases to be formed, to separate the chloride of silver so produced by filtering, and to test the filtered liquor by solution of ferrocyanide of potassium, which, if copper be present, will produce either a reddish-brown colour, or precipitate insoluble in hydrochloric acid. This is by far the best test, at least $\frac{1}{20000}$ of metallic copper may be thus detected.

4. The presence of *lead* is ascertained by dissolving another portion of the nitrate of silver under examination, and adding hydrochloric acid, which will produce a white curdy precipitate ; if a slight excess of ammonia redissolves the whole of that precipitate, the nitrate of silver was pure ; but if, on the contrary, an insoluble portion remains, it is chloride of lead.

5. The presence of lead may also be detected by dissolving a portion of the nitrate of silver under examination in a large quantity of water, adding muriatic acid in sufficient quantity only to precipitate the silver, filtering, and passing a stream of sulphuretted hydrogen through the solution, a black precipitate of sulphuret of lead will then be produced. Copper, if present, would be precipitated also by sulphuretted hydrogen in the state of black sulphuret of copper, but its presence will have been indicated before by the blue colour imparted to the solution by ammonia.

6. Supposing both *copper* and *lead* to be present in the solution of nitrate of silver, the quantitative determination may be effected as follows :—Dissolve a given weight of the nitrate of silver under examination in a very large quantity of pure water, and add dilute hydrochloric acid thereto, with care, avoiding a large excess of acid, for chloride of lead is less soluble in water which contains an excess of acid than in pure water ; warm the liquor a little, all the silver will be thus precipitated in the state of chloride of silver ; when it has completely subsided and the supernatant liquor has become quite clear, it is collected on a filter, washed with water slightly acidified with nitric acid, thoroughly dried, and then fused in a small porcelain crucible. 144 grains of fused chloride of silver represent 170 grains of nitrate of silver, or, in other words, each grain of nitrate of silver operated upon, should yield 0.847 grain of fused chloride of silver. The chloride of silver should not be ignited with the filter, the latter should be scraped as clean as possible, and then burnt separately on the cover of the crucible, and the ashes introduced into the crucible with the chloride.

7. The liquor filtered from the precipitated chloride of silver should now be treated by sulphuric acid, which will produce a precipitate of sulphate of lead ; the whole should then be evaporated to dryness, the heat being increased towards the end, so as to expel the excess of sulphuric acid. Water is now poured on the dry mass, which will redissolve the sulphate of copper, but will leave the sulphate of lead in an insoluble state. The sulphate of lead is then separated by filtering, washed with spirits of wine, or with water acidified with sulphuric acid, dried, and ignited in a porcelain crucible without the filter, which should be burnt separately on the cover of the crucible, as for chloride of silver. 152 grains of sulphate of lead represent 104 of lead, or 166 of nitrate of lead, or each grain of sulphate of lead represents 0.68287 grain of lead, or 0.73563 grain of protoxyde of lead, and, consequently, 1.091 grain of nitrate of lead. It is seldom, however, that nitrate of silver contains more than traces of lead and of copper, in which case, after having ascertained the presence of lead by sulphuric acid, as just said, and filtered the liquor from whatever precipitate or turbidness which this may have produced, the filtered liquor should be tested for copper, either or both by ammonia and ferrocyanide of potassium. Ammonia produces a blue colour ; ferrocyanide of potassium a reddish-brown precipitate.

8. Admitting, however, that copper is present in ponderable quantities, a solution of caustic potash should now be poured into the liquor filtered from the sulphate of lead produced, in order to precipitate the oxyde of copper, and the whole is boiled. Whilst doing so, the hydrate of protoxyde of copper, which was a bulky, bluish precipitate, is transformed, by ebullition with the caustic potash, into a heavy brownish-black precipitate, which is pure protoxyde of copper ; it should be collected on a filter, washed with hot water, dried, ignited with the filter in a platinum crucible, which, after ignition, should be immediately closed, and weighed as soon as cold, for otherwise, an increase of weight will be produced, owing to an absorption of moisture. 40 of oxyde

of copper represent 94 of nitrate of copper. But, as we said, only traces of copper are ordinarily present.

9. *Nitrate of potash*, on the contrary, is very often met with, as we said, in considerable quantity in the nitrate of silver of commerce. The presence of this salt may be detected by placing a portion of the suspected nitrate upon a piece of charcoal, and heating it thereon before the blowpipe; deflagration takes place, and if the spot on which the nitrate of silver was deflagrated, being now wetted and tested with a strip of tumeric paper, or of reddened litmus paper, turns the first brown, and the second blue, it is a sign that nitrate of potash was present, the alkali of which has been liberated by the deflagration. The presence of nitrate of potash may also be recognized by dissolving a given weight of the suspected nitrate of silver in distilled water, and pouring into the solution a quantity of hydrochloric acid, just sufficient to precipitate the silver in the state of chloride of silver, which is separated by filtering; the filtered liquor should then be evaporated to dryness, which will leave as residuum the whole of the nitrate of potash.

10. For chemical purposes, the presence of nitrate of potash does not generally interfere with the usual re-actions of nitrate of silver, and potash may therefore be employed to separate the copper in the preparation of nitrate of silver from silver coins, which is done by carefully adding potash to the solution of the coin in nitric acid, until the precipitate at first produced, and which was blue, begins to turn brown. The liquor filtered from that precipitate contains nothing else but nitrate of silver and nitrate of potash. The principal objection to nitrate of potash in nitrate of silver, sold as such, is the unwarrantable cost, potash being in that case sold at the price of silver. But *pure* nitrate of silver is so easily prepared by simple solution in nitric acid, and ignition in a crucible, that it should always be obtained pure.

11. The aqueous solution of pure nitrate of silver should be completely precipitated by dilute hydrochloric acid, so that the

filtrate being evaporated to dryness, or a drop of the filtrate being evaporated on a strip of platinum foil should leave no residue whatever ; if it does, it is an impurity.

NITRATE OF SODA.

NITRE (CUBIC).

1. Cubic nitre, or *Chili saltpetre*, is the commercial name of nitrate of soda (Na O, NO_5), which is found in a native state, in extensive deposits, under a thin stratum of clay, on the boundary coasts between Peru and Chili. Nitrate of soda being hygroscopic, cannot be used in the manufacture of gunpowder, but nitrate of potash is sometimes made from it, in countries where potash is cheap, by treating the nitrate of soda by carbonate of potash ($\text{Na O, NO}_5 + \text{KO, CO}_2 = \text{Na O, CO}_2 + \text{KO, NO}_5$), that is to say, the potash of the carbonate of potash combines with the nitric acid of the nitrate of soda, and the soda of the nitrate of soda combines with the carbonic acid of the carbonate of potash, which thus becomes carbonate of soda ; the carbonate of potash becomes therefore carbonate of soda, and the nitrate of soda becomes nitrate of potash. Or, instead of carbonate of potash, chloride of potassium is frequently used for the same purpose. The nitrate of soda and the chloride of sodium being first dissolved in boiling water, and mixed together in proper proportions, chloride of sodium, being the less soluble salt, falls first, and nitrate of potash remains in the liquor, from which it is deposited in crystals in cooling. The principal use of nitrate of soda, however, is for the manufacture of nitric acid, by decomposing it with sulphuric acid, and as a source of nitric acid in the manufacture of sulphuric acid. This salt is also employed as manure, &c.

2. The nitrate of soda of commerce is met with in the

form of a moist, dirty, brownish mass, containing, when not adulterated, generally more than 95 per cent. of the salt, and frequently only a mere fraction of chloride of sodium or other impurities.

3. The mode of ascertaining the commercial value of nitrate of soda is exactly the same as for nitrate of potash, to which the reader is referred.

NITRE.—See *Nitrate of Potash*.

[NITRE (CUBIC).—See *Nitrate of Soda*.]

NITRIC ACID.

AZOTIC ACID—AQUAFORTIS.

1. Nitric acid is a compound of nitrogen and oxygen (NO_3), which has never yet been obtained *free* in the anhydrous or dry state. The most concentrated acid contains still 14 per cent. of water. The density of nitric acid diminishes in proportion to its state of dilution.

2. The specific gravity of commercial nitric acid is generally 1.31, but it is sometimes met with as high as 1.513, which corresponds to 85.7 per cent. of real acid, in which state it is a colourless liquid, of a strong, disagreeable, suffocating odour ; its taste is excessively acid and corrosive ; it emits white, irritating fumes in the air, but when diluted it does not fume ; it rapidly destroys organic substances, and stains them yellow. The commercial concentrated acid has generally a yellowish colour. When the acid is known to be pure, which may be ascertained as described further on, its strength may be determined by taking its specific gravity. The following table by Dr. Ure, shows the strength of the acid corresponding with its density.

NITRIC ACID.

Specific Gravity.	Liquid Acid in 100.	Dry Acid in 100.	Specific Gravity.	Liquid Acid in 100.	Dry Acid in 100.
1.5000	100	79.700	1.2947	50	39.850
1.4980	99	78.903	1.2887	49	39.053
1.4960	98	78.106	1.2826	48	38.256
1.4940	97	77.309	1.2765	47	37.459
1.4910	96	76.512	1.2705	46	36.662
1.4880	95	75.715	1.2644	45	35.865
1.4850	94	74.918	1.2583	44	35.068
1.4820	93	74.121	1.2523	43	34.271
1.4790	92	73.324	1.2462	42	33.474
1.4760	91	72.527	1.2402	41	32.677
1.4730	90	71.730	1.2341	40	31.880
1.4700	89	70.933	1.2277	39	31.083
1.4670	88	70.136	1.2212	38	30.286
1.4640	87	69.339	1.2148	37	29.489
1.4600	86	68.542	1.2084	36	28.692
1.4570	85	67.745	1.2019	35	27.895
1.4530	84	66.948	1.1958	34	27.098
1.4500	83	66.155	1.1895	33	26.301
1.4460	82	65.354	1.1833	32	25.504
1.4424	81	64.557	1.1770	31	24.707
1.4385	80	63.760	1.1709	30	23.900
1.4346	79	62.963	1.1648	29	23.113
1.4306	78	62.166	1.1587	28	22.316
1.4269	77	61.369	1.1526	27	21.519
1.4228	76	60.572	1.1465	26	20.722
1.4189	75	59.775	1.1403	25	19.925
1.4147	74	58.978	1.1345	24	19.128
1.4107	73	58.181	1.1286	23	18.331
1.4065	72	57.384	1.1227	22	17.534
1.4023	71	56.587	1.1168	21	16.737
1.3978	70	55.790	1.1109	20	15.940
1.3945	69	54.993	1.1051	19	15.143
1.3882	68	54.196	1.0993	18	14.346
1.3833	67	53.399	1.0935	17	13.549
1.3783	66	52.602	1.0878	16	12.752
1.3732	65	51.805	1.0821	15	11.955
1.3681	64	51.068	1.0764	14	11.158
1.3630	63	50.211	1.0708	13	10.361
1.3579	62	49.414	1.0651	12	9.564
1.3529	61	48.617	1.0595	11	8.767
1.3477	60	47.820	1.0540	10	7.970
1.3427	59	47.023	1.0485	9	7.173
1.3376	58	46.226	1.0430	8	6.376
1.3323	57	45.429	1.0375	7	5.579
1.3270	56	44.632	1.0320	6	4.782
1.3216	55	43.835	1.0267	5	3.985
1.3163	54	43.038	1.0212	4	3.188
1.3110	53	42.241	1.0159	3	2.391
1.3056	52	41.444	1.0106	2	1.594
1.3001	51	40.647	1.0053	1	0.797

3. The specific gravity of nitric acid is very often artificially augmented by dissolving *nitrate of potash* in it; this sophistication, however, is very easily detected by evaporating the acid, when the nitrate so added will be left behind. But the best way of ascertaining the real value of nitric acid is by determining its saturating power, as has been indicated in the article on acidimetry.

4. The nitric acid of commerce is ordinarily contaminated by *sulphuric* and *hydrochloric acids*, or by *chlorine* or *chlorides*.

5. The presence of sulphuric acid is detected by diluting a portion of the nitric acid with pure water, and adding a solution of nitrate of baryta; if this produces a white precipitate, insoluble in water, in acids, and likewise in ammonia, it is sulphate of baryta, and it indicates, of course, the presence of *sulphuric acid*. If the precipitate is in ponderable quantities, it should be first boiled with the acid liquor in which it has been produced, allowed to settle, filtered, washed, dried, ignited, and weighed. 117 grains of sulphate of baryta represent 40 of dry sulphuric acid, or each grain of sulphate of baryta represents 0.34368 grain of dry sulphuric acid.

6. The presence of *chlorine*, or of *chlorides*, or of *hydrochloric acid*, is detected by diluting the nitric acid with pure water, and adding a solution of nitrate of silver. If a white, curdy precipitate, or an opaline tinge, or turbidness is produced, insoluble in nitric acid, but which immediately disappears by pouring an excess of ammonia, and re-appears by adding an excess of acid, it is chloride of silver; in which case the acid liquor should be moderately heated, in order to promote the settling of the precipitate, which may then be collected on a filter, as small as possible, washed, and carefully dried. It should then be introduced into a counterpoised porcelain crucible; the filter, being scraped clean, is then burnt upon the cover of the crucible, and the ashes are added to the precipitate in the crucible; the mass is then fused, and after

cooling, it is weighed. 145 grains of chloride of silver represent 36 grains of chlorine, or 37 grains of hydrochloric acid ; or each grain of fused chloride of silver represents 0.24729 grain of chlorine, or 0.25427 grain of hydrochloric acid.

7. Before testing the acid, as just said, do not omit to dilute it with three or four times its bulk of distilled water, for otherwise a precipitate would be produced, but which is nothing else than nitrate of baryta and nitrate of silver, which might simulate the presence of sulphuric acid and of chlorine. Such precipitates, however, immediately disappear by an addition of water.

8. When nitric acid contains fixed substances, they are easily detected by evaporating a small quantity of the acid in a watch-glass or small capsule, in which case a fixed residuum will be left. Pure nitric acid is entirely volatilizable by heat.

9. Impure nitric acid can always be easily purified by adding to it a sufficient quantity of nitrate of silver, in order to precipitate the chlorine and sulphuric acid, decanting the acid from the precipitates produced, and distilling it in a glass-retort and glass-receiver, taking care not to use either lute or cork. If done with care, and at a moderate heat, the acid which passes over is perfectly white.

NITRIC OXYDE OF MERCURY.—See *Peroxyde of Mercury*.

OILS.

1. There are two kinds of oils.—The *fixed oils*, which, as their name implies, do not sensibly evaporate at the ordinary temperature, and which do not distil at the temperature of boiling water ; such oils have only a faint odour, similar to that of the substances from which they have been extracted, and have scarcely any taste, at least when fresh. Their

gravity is less than water, and ranges between 0.913 and 0.936. They permanently stain paper, and render it translucent. *Volatile*, or *essential oils*, when distilled with water, pass over at 212°, or when distilled by themselves, at or under 320° Fahr., they have a caustic, hot, acrid taste, and aromatic odour; their specific gravity ranges between 0.847 and 1.096.

2. **FIXED OILS.**—According to Mr. Heidenreich, of Strasburg, the purity of the fixed oils of commerce may be approximatively determined, and the admixture of cheaper oils detected, in the following manner:—

1°. *By observing the peculiar odour of the oil when gently heated.*

For this purpose, a few drops of the oil under examination should be poured in a small porcelain or platinum capsule, and exposed to the heat of a spirit-lamp. The odour which is evolved, immediately suggests that of the plant or of the animal from which it has been obtained, and this characteristic is valuable, more especially if observed in conjunction with the genuine oil, and furnishes accurate indications of the presence of linseed-oil, whale-oil, train-oil, or rape-oil, in any mixture. M. Penot, however, observes, that the odour of the oil is not always a safe criterion, since an oil of the same fruit, or nut, has not always the same odour. This is especially the case with olive-oil, the odour of which differs according to the different places where it has been grown. The same is the case with other oils, if cold drawn, or if expressed under the influence of heat.

2°. *By the action of concentrated sulphuric acid.*

“By mixing a small quantity of concentrated sulphuric acid with some oil (in proportion of about 1 or 2 parts of the former to 100 parts of oil), very intense action immedi-

ately ensues, the temperature increases, and the mixture becomes coloured.

“ A plate of white glass being laid over a sheet of white paper, if we place on the former from 10 to 15 drops of oil, and then add thereto one small drop of sulphuric acid of $66^{\circ} = 1.632$ specific gravity, a colour will soon be produced without stirring, differing according to the oil employed.

“ In the case of *rape-oil*, there will gradually form, at a certain distance from the drop of sulphuric acid, a greenish-blue ring ; whilst towards the centre, where the action is more violent, light yellow-brown streaks may be observed.

“ *The expressed oil of black mustard-seed* likewise assumes a tinge of bluish-green ; but the quantity of oil must, in this case, be increased to 25 or 30 drops.

“ In *train-oil*, obtained from the whale or stock-fish, a very peculiar motion occurs, commencing at the centre and extending to the outside, whilst a red colour is observed, which grows more and more vivid, until after ten or fifteen minutes, when the margin assumes a violet tinge, which, in the course of about two hours, becomes uniform throughout the mixture.

“ *Olive-oil* instantly assumes a pale yellow colour, which afterwards becomes yellowish-green.

“ In *poppy-oil*, and that obtained from sweet almonds, the colour approaches to that of the greenfinch, and afterwards becomes of a dead yellow hue.

“ In *linseed-oil*, a drop of acid produces a beautiful dark brownish-red web, which is gradually converted into a brownish black.

“ *Tallow-oil* (called by the trade oleic acid), is rendered brown.

“ If, instead of allowing the sulphuric acid to act on the oil undisturbed, both fluids be stirred up with a glass-rod after adding the drop of sulphuric acid, the phenomena mentioned appear in different order.

“*Rape-oil* then assumes a uniform brown colour, without a tinge of red ; and if, instead of one drop of acid, five or six are added, and mixed with the oil, the whole mass becomes of a dead brown-red colour, not very intense, remaining green only on the edges.

“By doubling or trebling the expressed oil of black mustard seed, the quantity tested gives rise to a similar action, with the exception that the colour is somewhat less bright.

“*Train-oil* instantly assumes, when stirred, a lively brown-red colour, which finally passes to dark brown and violet, without a hue of green. If mixed with five or six drops of acid, the colour is much more intense, and the violet colour sooner appears.

“*Seal-oil* assumes a yellowish-gray colour. If, however, thirty drops of oil are taken instead of ten, a colour slightly approaching to green-blue also appears, so that one drop more changes it into gray. On the addition of five or six drops of acid, it receives a lively orange-yellow tint.

“The oils from the olive, poppy, and sweet almonds, all assume a yellow colour, more or less dingy or gray ; and by the addition of more acid, the action is rendered far more violent.

“If *linseed-oil* is stirred with the rod, as before mentioned, a brownish-black lump forms, and by adding five or six drops of acid, the whole forms a resinous, black, and persistent mass. It is true that all other oils likewise become plastic by the addition of greater or smaller quantities of acid ; none, however, to a similar degree, and with a colour so black, as linseed oil. The oil obtained from tallow assumes a dark, dirty brown colour, which does not vary in tint by the addition of more acid.

“In trade, it seldom occurs that a better oil is mixed with an inferior one. Oil of almonds, olives, and codfish-oil, will, therefore, never be used for adulterating rape-oil, but probably train, or, perhaps, linseed-oil, and sometimes poppy oil. If we are led, therefore, by the odour, to infer an adul-

teration—for instance, by train-oil, which occurs the most frequently—it is only necessary to place from ten to fifteen drops of rape-oil, the purity of which is undoubted, together with as much train-oil, and an equal quantity of the oil whose purity is suspected, and to add to each of them a small drop of sulphuric acid. From the colour produced, an inference may be drawn as to the purity of the oil, and by the difference of tinges from the vivid red of the train-oil, and the bluish-green of rape-oil, the extent of adulteration may be ascertained. In this manner I detected adulterations made with half the quantity of an inferior oil; and the areometer bore further testimony to the precision of my observations.

“In undertaking an experiment, the commencement of the re-action must be accurately observed, with the several oils placed beside each other; for the colours, after a quarter of an hour has elapsed, are less distinct, and the mixture should, for the purpose of attaining to greater certainty in the first experiment, be left undisturbed; in a second experiment it is stirred with the glass rod. It is likewise necessary to avoid employing more than one drop of the acid to ten drops of oil, since otherwise the re-action which ensues is too violent.

“If the presence of linseed-oil be suspected in train-oil, this will be discovered, if the mass is left undisturbed, by a rather intense brownish-red colour; if disturbed, by a brownish-black colour.

“The adulteration by poppy-oil is seldom met with in commercial rape-oil, because it is commonly much dearer than the latter. In the present year, however, the reverse was the case, and rape oil was found to have been adulterated with poppy oil. In this case the colour produced is of a very slight bluish-green, approaching somewhat to yellow, but not sufficiently distinct to admit of an inference being drawn, as to the adulteration, with perfect certainty. In such cases the specific gravity of both oils must be received as the sole criterion for identifying them.

“It has been reported that tallow-oil has several times

been mixed at Paris with rapeseed-oil: besides the brownish colour produced by sulphuric acid, the tallowy smell, the brown colour, the acid re-action, and last although not least, its density, which is less than any other of the fixed oils, are such decisive characteristics, that we must be blind indeed, if we do not instantly discover this fraud."

4. Instead of 10 or 15 drops of oil M. Penot directs to employ 20 drops, &c.

"M. Penot, in a report on the preceding researches of M. Heidenreich, made in the name of the chemical *Comité de la Société Industrielle de Mühlhausen*, makes the following additional remarks to the three means suggested by M. Heidenreich, for discovering the adulteration of oils.

"1. As regards the detection of adulteration by the odour of an oil, it must be observed, that the same oil—that is to say, an oil of the same fruit or nut—has not always the same odour. This is especially the case with olive-oil; the odour of which differs according to the different places where it has been grown. The same is the case with other oils, if cold drawn, or expressed under the influence of heat.

"2. *By the action of sulphuric acid.*—M. Penot directs us to employ 20 drops of oil, which he places on capsules of white porcelain. He likewise found that every different kind of oil indicated a different re-action, which, however, did not entirely agree with the results obtained by M. Heidenreich. Besides this, M. Penot employed a saturated solution of chromate of potash in sulphuric acid, always in the proportion of 1 drop to 20 drops of oil, which were stirred together. The following table shows the difference of the re-actions produced by both re-agents on twenty different kinds of oil. It is, however, necessary, in order to insure greater certainty, that we should first compare the effects of them on a pure oil, when any oil is suspected of having been adulterated, since it is difficult to remember precisely the colours produced by re-agents, and still more difficult to convey such a definition as will be understood by every one.

ACTION OF ONE DROP OF THE RE-AGENT ON TWENTY DROPS OF OIL.

Name of the Oil.	Sulphuric Acid.		Solution of Bichromate of Potash
	Not Stirred.	Stirred.	
Oleic acid	Reddish spots with reddish circles.	Reddish-brown	Reddish-brown.
Oil of sweet almonds.	Greenfinch - yellow with orange spots.	Dirty-green.....	Yellowish small lumps.
Whale train-oil	Reddish small lumps on brown ground.	Lees of wine	Brownish-red small lumps on a brown ground.
Hemp-oil.....	Brown small lumps on a yellow ground	Greenish-brown	Yellow small lumps on a green ground.
Rapeseed-oil	Scarcely perceptible spots.	Green.....	Yellow small lumps on a ground coloured green by the chrome.
Liver train-oil	Dark-red	Dark-red.....	Dark red.
Linseed-oil from the Upper Rhine.	Dark reddish-brown	Brown small lumps on a gray ground.	Brown small lumps on an almost colourless ground.
Linseed-oil from Paris.	Reddish-brown, less dark-coloured.	Clotted brown on a green ground.	Brown small lumps on a ground coloured green by the chrome.
Madia sativa.....	Slightly reddish-brown underneath a thin layer (film), approaching to gray.	Olive-green.....	Light-brown small lumps on an olive-coloured ground.
Rapeseed-oil, one year old, pressed out after exposing the seeds to a gentle heat.	Green	Bluish-green	Yellow small lumps on a chrome-green ground.
Rapeseed-oil, one year old, pressed out at a somewhat higher temperature from another factory.	Green	Bluish-green	Yellow small lumps, more numerous, on a dirty-green ground.
Rapeseed-oil, fresh.	Green.....	Bluish-green	Yellow small lumps on a ground coloured green by the chrome.
Nut-oil	Yellowish-brown...	Clotted, dark-brown	Small brown lumps.
Nut-oil, one year old.	Yellow	Dirty-brown, less dark-coloured.	Small brown lumps.
Nut-oil, one year old, from another factory.	Orange-yellow.....	Dirty-brown.....	Small brown lumps.
Olive-oil, from Beaucaire.	Slightly yellow.....	Dirty-brown	Olive brown.
Olive-oil	Orange-yellow.....	Brownish-gray	Brown.
Olive-oil, expressed by engine from fermented olives.	Orange-yellow.....	Brownish-gray	Brown.
Poppy-oil, fresh, cold drawn.	Yellow spots.....	Brownish olive-coloured.	Small yellow lumps on a white ground.
Poppy-oil, one year old, expressed at a slight heat.....	Greenish spots.	Slightly green	Small yellow lumps on a green ground.
Neatsfoot-oil	Yellow slight spots.	Dirty-brown	Brown spots on a brown ground.
Castor-oil, native...	Yellow slight spots.	Almost colourless...	Slightly green.

“By perusing this table, M. Penot continues, it will be observed that the same oil does not, under all circumstances, yield precisely similar results with the same re-agent. This depends on the place of their growth, their age, and the manner of pressing. If, however, any oil be examined comparatively with a perfectly pure one, the proof of adulteration may be rendered, if not certain, at least probable, by noting the difference. Thus I obtained, by adding 1 part of either whale-train or linseed-oil, or oleic oil, to 10 parts of rapeseed-oil, the following results :—

Name of the Oils.	Sulphuric Acid.		Solution of Bichromate of Potash.
	Not Stirred.	Stirred.	
Rapeseed-oil with whale-train.	More red ground than with rape seed oil	Brownish-olive coloured.	Small reddish lumps on a gray ground.
Rapeseed-oil with linseed oil.	No perceptible difference from the rapeseed-oil	Olive-coloured.....	Small and more numerous red lumps on a very dark-green ground.
Rapeseed-oil with oleic oil.	No perceptible difference from the rapeseed-oil.	Greenish-brown.....	Small brownish lumps on an olive-coloured ground.

“The adulteration being ascertained as far as is possible, the oil is then tested by endeavouring to discover the adulterating oil, either by re-agents, or by its odour when gently heated, as before described. This having been found out, small quantities of the suspected oil are added to a perfectly pure oil of the kind under examination. Every mixture is then tested by the re-agents, until precisely similar results are obtained as those yielded by the oil under examination. Thus the proportions of the two mixed oils will be discovered by approximation.

3. “*The density of oils.*—Every oil supposed to come from the same plant, or the same animal, has its peculiar density, which, at the same temperature, never can deviate more than some few thousandths.

“ This density is, in oils hitherto examined, between 0.900 [tallow-oil] and 0.96 [castor-oil—*Ricinus-oil*] ; water, at 15° C. = 59° F. taken as unity. This answers, on the centrifgrade alcoholmeter of Gay Lussac, to the densities from the 66th degree to the 34th. For greater perspicuity I have added the table arranged by Schübler, together with the degrees of Gay Lussac’s alcoholmeter. We deemed it best to add the latter, since it is very generally used, and saves employing other instruments. It is only necessary to procure a scale, the degrees of which are at proper distances. Besides this, an oil-balance could easily be arranged, on the same principle, by placing, at the temperature of 15° = 59° F., the number 0.970 as the extreme point at one end of the scale, or a little higher than the density of castor-oil, and for the extreme density of oleic acid .900, and dividing the intervals between these into 70 degrees, in such a manner that each degree answers to a thousandth part on the table of densities.

TABLE OF THE SPECIFIC GRAVITY OF
SOME OILS.

Name.	Specific Gravity.	Degrees on Gay Lussac's Alcohol-meter.	Degrees on Fischer's oil-balance.
Tallow-oil.....	0.9003	66	
Rapeseed-oil (Navette) (<i>Brass. napus oleifera</i> Dec.) }	0.9128	60 $\frac{3}{4}$	{ 37 to 38 Purified 38 to 39
Rapeseed-oil (Colza) } (<i>Brass. campestr. oleif.</i>) }	0.9136	60 $\frac{1}{2}$	
Summer rapeseed-oil (levatte) } (<i>Brass. præcos</i> Dec.) }	0.9139	60	
Olive-oil.....	0.9176	58 $\frac{2}{3}$	37 to 38
Beechnut-oil.....	0.9225	56	
Purified whale-train	0.9231	95 $\frac{4}{5}$	

TABLE OF THE SPECIFIC GRAVITY OF SOME OILS.

Continued.

Name.	Specific Gravity.	Degrees on Gay Lussac's Alcohol-meter.	Degrees on Fischer's oil-balance.
Poppy-oil.....	0.9243	55 $\frac{1}{4}$	32 to 33
Dötter-oil (caméline) {	0.9252	54 $\frac{3}{4}$	31 to 32
Myagrum (sativum) }			
Linseed-oil.....	0.9347	50	29 to 30
Castor-oil.....	0.9911	33 $\frac{3}{4}$	
Oil of sweet almonds.....	0.932		
Codfish-oil.....	0.923		
Filberts (oil of).....	0.916		
Hempseed-oil.....	0.926		
Walnuts (oil of).....	0.923		
Oil of madia sativa.....	0.935		
Do. do.	0.928		

“By examining this table, we find, as regards the different commercial oils, especially those commonly used for adulteration, an obvious difference of density : thus, for instance, the different rapeseed-oils weigh at 15° between 60 $\frac{3}{4}$ and 60° according to the alcoholmeter, whilst beech-nut-oil weighs 56° ; fish train, 55 $\frac{4}{5}$ ° ; poppy-oil, 55 $\frac{1}{4}$ ° ; dötter-oil (caméline), 54 $\frac{3}{4}$ ° ; and linseed-oil, 50°. In cases, therefore, in which rapeseed-oil indicated less than 60°, it might be inferred with certainty that it had been mixed with another oil. The same would be the case with olive oil, if indicating more or less than 58 $\frac{1}{2}$ °. It is true that the knowledge of the density of an oil does not precisely indicate by what oil the adulteration may have been performed ; but, in this case, we can recur to the odour which the oils evolve when exposed to heat, and to the comparative experiments, previously mentioned, with sulphuric acid. The oil which has been employed for adulteration having been ascertained, the alcoholmeter shows with certainty to what degree the adulteration extends.

“This latter means of examination has indeed already been employed by some in the trade ; and I am astonished that it is not more generally applied, since it is a sufficiently

good guide alone, and, if combined with the two others, I doubt if any one could be deceived."

5. M. Penot thinks, however, that oils of the same name, but not identical, never have the same density.

"The editor of the *Journal f. Prakt. Chemie*, remarks, that he has not found, in the course of his own experience, any difference in the specific gravity in oils of the same kind obtained from different places and grown in different years ; and that in Saxony an areometer (or oleometer) is generally used for testing oils, constructed by the instrument-maker Fischer, of Leipzig, which indicates the specific gravity of oils in such manner, that pure rapseed-oil is indicated by 37 to 38°; hemp-oil by 30° to 31°, &c. This oil-balance is very correct and useful. Another assistance in such examinations is the capillarimeter, an instrument for indicating the quantity of each oil which falls from a certain sized point under given circumstances."

6. When *oil of almonds* is mixed with oil of poppies, the taste is sometimes sufficient to detect the presence of the latter oil ; and if such an oil be agitated in a phial, it produces bubbles of air, which stick to the sides of the phial, which is never the case with pure oil of sweet almonds.

7. *Oil, or butter of cocoa*, is always solid at the ordinary temperature, of a yellowish-white colour ; its fracture is clean, and it has a soft, agreeable flavour, and a peculiar odour. It fuses at 77° Fahr.

8. When butter of cocoa has been well prepared, it may be kept for two or three years without becoming rancid ; but that which is met in trade being often adulterated with tallow, or veal or mutton-suet, very soon turns bad ; but this fraud is generally perceptible, because, in that case, the flavour of the spurious article is not agreeable, like that of the genuine oil, and it leaves afterwards in the mouth a taste of tallow, which cannot be mistaken ; the odour of tallow is

readily recognized by heating it as directed by M. Heidenreich.

9. But of all these oils, the dearest (except oil of almonds), and, consequently, that which is most subject to adulteration, is *olive-oil*; and the oils with which it is most generally mixed are those of nuts and of poppies. The latter, more especially, is employed for the purpose, because it may be mixed in considerable proportion with olive oil without materially altering the taste of the latter, whilst its price is only half that of olive-oil.

10. As with oil of almonds, when pure olive-oil is shaken in a flask or phial, its surface remains even, but if mixed with oil of poppies, it becomes covered with small air bubbles.

11. When pure olive oil is immersed in pounded ice, it becomes completely solidified, but if it is adulterated with oil of poppies, it solidifies only in part; and if the latter oil forms more than one-third of the bulk, the oil does not become solid at all.

12. M. Poutet recommends the following method for the detection of oil of poppies in olive oil, namely:—dissolve six parts of mercury in seven and a half parts of nitric acid of sp. gr. 1.35, heat need not be applied; mix two parts of this solution with 96 parts of the oil under examination, and shake the mixture every half hour, or oftener. If the oil is pure, the mixture, after seven hours in summer, or three or four hours in winter, will have congealed into a thick magma, and in 24 hours it will have so far solidified that some little force must be employed to sink a glass rod through it. The other edible oils do not combine with nitrate of mercury, and if the olive-oil contains some other oil, it thickens, but never becomes solid. If the quantity of foreign oil forms more than one-eighth of the bulk, it separates from the thickened mass into a distinct layer. The compactness of the mass therefore is proportionate to the quantity of the foreign oil. If the olive-oil contains its own bulk of

another oil, one half of the mixture is solid, and the other half is liquid. A temperature of about 90° Fahr. is the best for the experiment, for the oil and coagulum separate then perfectly from each other. If the oil has been adulterated with animal fat, the mixture will coagulate in five hours; in this case the coagulation consists of the animal fat, whilst the olive-oil floats on the surface, and may be decanted. If the coagulum or solidified portion be then heated, it exhales the odour of melted tallow.

13. M. Boudet has shown that, in Mr. Poutet's method above related, it is not the nitrate of mercury but the hyponitrous acid contained in the test-liquor which solidifies the olive-oil; and he found that one half grain of hyponitrous acid, mixed with three times its own weight of nitric acid, was capable of solidifying 100 grains of olive-oil in about 78 minutes.

14. The fixed oils which may be solidified, when treated in the above manner, are those of sweet almonds, of filberts, and of colza; but the drying oils, except castor-oil, are not solidified by that treatment. Each of these oils requires different lengths of time to become solid, as shown in the following table, in which 100 parts of the oils mentioned were treated by a mixture of nine parts of nitric, and one of hyponitrous acid:—

Oils.	Colours developed by the addition of the mixture.	Number of minutes necessary to solidify oils.	Proportions.
Olive-oil.....	Greenish-blue.....	73	10.0
Oil of sweet almonds....	Dingy-white	160	22.2
— filberts.....	Greenish-blue	103	14.0
— acajou	Lemon-yellow	40	6.0
— Ricini (castor-oil)	Golden-yellow.....	603	82.6
— Colza	Yellowish-brown.....	2400	328.0

15. The presence of the oil of poppies may be easily recognized by its retarding effect; 1 per cent. of oil of poppies retards the solidifying at least 40 minutes.

16. Olive-oil is sometimes adulterated with *honey*; this sophistication may be recognized by treating the oil with hot water, which dissolves the honey; after shaking the mixture well, it should be left at rest; the oil then separates from the water which has dissolved the honey. The oil may then be decanted, and by evaporation the honey is left behind.

17. The presence of *fish-oil* is readily detected in vegetable oils, by passing chlorine through them; in which case the mixture turns black.

18. Besides the tests above described, an instrument called *elaiometer* was contrived by M. Gobby, by which the purity of olive-oil may be estimated. The *elaiometer* is constructed on the principle of the hydrometer, but as the differences of density are inconsiderable, the bulb of the instrument is very large, and the tube or stem is very narrow. The instrument at $54^{\circ}.5$ Fahr. marks 0° in poppy-seed oil, and 50° in pure olive-oil. The *modus operandi* is as follows:—the oil to be tested is first brought to a temperature of $54^{\circ}.5$ Fahr., which is readily accomplished by plunging the glass-cylinder containing it into cold water, or else the result of the operation may be corrected, if the temperature be above 54.5 Fahr. by deducting 2 from the degree indicated by the *elaiometer* for each degree of temperature, and if the temperature be lower than 54.5 , by adding 2 for every degree below $54^{\circ}.5$ Fahr.

19. For example, let us suppose that the temperature at the time of the experiment is 60° Fahr., and the *elaiometer* indicates 61° .

Then $60^{\circ}.0$ Temperature at the time of the experiment.

54.5 Normal temperature.

5.5 Difference.

Density indicated by the *elaiometer* . . . 61.0

The difference $5.5 \times 2 =$. . . 11.0

Real density 50.0

The oil therefore is pure.

20. Or, let us suppose that the temperature observed at the time of the experiment is 52, and that the elaiometer indicates 45.0.

54.5 Normal temperature.

52.0 Temperature at the time of the experiment.

2.5 Difference.

Density indicated by the elaiometer 45.0

The difference $2.5 \times 2 =$ 5.0

Real density. 50.0

The real density being 50, the oil is called pure.

21. The degrees of the elaiometer are as follows:—

Pure olive oil		50	degrees.
Olive oil mixed with 4 per cent. of			
oil of poppies		48	„
10 per cent.	do.	45	„
14 do.	do.	43	„
20 do.	do.	40	„
30 do.	do.	35	„
40 do.	do.	30	„

22. ESSENTIAL OILS.—The essential oils of commerce are often adulterated with *fixed* or *fat oils*, *spermaceti*, *rosin*, *tallow*, *balsam* of *copaiba*, *alcohol*, and *essential oils* of less value than the genuine oil.

23. The methods of detecting these fraudulent additions consist in pouring a drop of the essential oil upon a piece of paper, and evaporating it by heat. If the essential oil is pure, it will completely evaporate and leave no stain on the paper; but if adulterated with either a fixed or fat oil, tallow, spermaceti, rosin, or balsam, a greasy stain will be left on the paper, which will then appear transparent at that part.

24. *Alcohol* is detected by putting a few pieces of fused chloride of calcium into a flask with the essential oil under examination, and shaking the whole well. If the essential oil be pure, the pieces of fused chloride of calcium will remain unaltered; but if alcohol is present, they will dissolve and form a heavy liquid, over which the pure essence will float in a distinct stratum. The proportion of alcohol, however, may be too small to dissolve entirely the pieces of chloride of calcium, but if alcohol be present they will always show that they have been acted upon, their edges will be more or less rounded, which would not be the case if the essence was pure.

25. The presence of alcohol mixed with an essential oil is also most readily detected, because the addition of water immediately produces a milkiness.

26. According to M. Biral, the presence of alcohol in essential oils may also be detected by means of potassium, as follows:—Pour twelve drops of the oil in a watch-glass perfectly dry, and add a piece of potassium about the size of a pin's head. If the piece of potassium remains in the middle of the oil for twelve or fifteen minutes, it is a sign that the oil does not contain alcohol; but if, on the contrary, the potassium disappears in the course of five minutes, it is a sign that the oil contains more than four per cent. of alcohol, and if it disappears in less than one minute, the oil contains 25 per cent. of alcohol, or more.

27. The addition of alcohol to essential oils is a most usual adulteration.

28. As to the addition of cheaper essential oils to the genuine article, the fraud is best detected as follows:—

29. Pour a few drops of the essential oil under examination, upon a piece of blotting paper, and allow it to evaporate spontaneously. The difference of the smell towards the end will often enable the operator to detect the sophistication. *Essence of turpentine* is generally employed for the purpose. In that case it may be separated by adding alcohol of specific

gravity 0.84, (54.8 per cent. over proof) to the essential oil. The turpentine will be left in an insoluble state.

30. The specific gravity affords also another means of ascertaining the purity of essential oils, we therefore give here the specific gravity of the principal essential oils.

Essential oil of Amber	. . .	0.868
do. Aneth	. . .	0.881
do. Aniseed	. . .	0.9857
do. Bergamot	. . .	0.888
do. Cajeput	. . .	0.9274
do. Carraway	. . .	0.940
do. Cassia	. . .	0.832
do. Cinnamon	. . .	0.975 to 1.043
do. Cloves	. . .	1.036
do. Cumin	. . .	0.975
do. Fennel	. . .	0.929 to 0.997
do. Fusel or of grain	. . .	0.835
do. Juniper	. . .	0.911
do. Lavender	. . .	0.898
do. Do. rectified	. . .	0.877
do. Lemon	. . .	0.847
do. Mint	. . .	0.898
do. Nutmeg	. . .	0.948
do. Otto of roses	. . .	0.832
do. Rosemary	. . .	0.911
do. Sassafras	. . .	1.094
do. Turpentine	. . .	0.870
do. Wormwood	. . .	0.907

31. When the specific gravity of an essential oil is sufficiently different from that with which it is mixed, they may be separated from each other by agitating them for a long time with water, and leaving the whole at rest. The two oils will then separate in the order of their respective density.

32. The oil of *spic lavender* met with in commerce is seldom pure, and is generally a mixture of three parts of essence of turpentine with one of genuine oil of lavender.

This fraud may best be detected by pouring a few drops of the suspected oil on a piece of paper and evaporating it; or else by pouring a drop of it on the back of the hand and rubbing it with the finger, when evaporated the persisting smell of turpentine will be recognized.

33. The oil of *neroli* is generally adulterated with alcohol, or with oil of *petit grain*.

34. The presence of alcohol may be detected in the manner above related, but that of oil of *petit grain* is more difficultly recognized, and the suspected article had better be compared, by evaporation of a drop on the back of the hand, with the genuine oil.

35. *Otto of roses* is often adulterated with oil of Rhodes, which oil has an odour of roses, but otto of roses which has been mixed with that oil loses its butyrous consistence.

36. The *Chemical Times* for August 25, 1849, published the following remarks by Mr. Guibourt, on the "Means of determining the purity of the otto of roses."

"The high price of this article renders it a matter of great importance to be enabled to decide upon its purity. The following means, if used in combination, will leave no doubt upon this point.

"The physical characters can be but little depended upon; thus, the yellow colour with a tinge of green, and its point of congelation may be readily imitated. Its odour also is so powerful that a certain quantity of any other oil of a somewhat similar odour might be added without sensibly diminishing that of the otto. The manner in which it crystallizes is of a certain amount of importance. When, after having been liquefied by a gentle heat, it is allowed to cool slowly and at rest, it remains as it were transparent, in consequence of the thinness and the perfect transparence of its long and pointed crystals, which resemble the blades of daggers; and, on varying their position as regards the light, these laminae reflect all the prismatic colours. When the otto of

roses has been adulterated with any uncrystallizable oil, which requires that its property of congealing should be imparted by the addition of spermaceti, it presents, when solidified, a number of fine needles, which, however, are not transparent, but render the mass uniformly semi-opaque. But for this test to be of any value, the otto must be allowed to crystallize slowly and at rest ; otherwise it becomes nebulous and opaque, like that which has been adulterated.

“ The oil most frequently used for its adulteration is that of several species of pelargonium. The oils derived from the different species cannot be all identical, since M. Recluz has described one which is solid, whilst that which is met with in commerce is always liquid. The oil which I employed for comparison is called oil of geranium, and came from Nice. I also examined some oil of rosewood, which was distilled at Paris some years ago, and some of that found in commerce. Three re-agents will serve to distinguish the pure otto, iodine, nitrous acid vapour, and sulphuric acid.

“ *Test with iodine.*—A small quantity of iodine is placed in a small glass vessel with a wide mouth ; around it, watch-glasses are arranged, each containing one or two drops of the oils under examination, and the whole is covered with a glass-bell. At the end of a few hours the vapour of the iodine is found to have condensed upon every part of the interior of the glass-bell, and upon the glasses containing the oils ; but the margin of the watch-glasses containing the substituted oils is much more coloured than that of the glass containing the otto ; and, when the former oils become brown, the latter retains its natural colour. After some hours the vessel containing the iodine may be removed ; and then, the effect still continuing, the otto remains white, whilst the other oils become perfectly black. On exposing the watch-glasses to the air, the iodine which has condensed upon the margin of those containing the otto is volatilized, and the glass becomes almost colourless, whilst the others retain their black colour. I am satisfied that this test will serve, not only to determine

the nature of the otto of roses, but also whether any oil of geranium or rosewood is present in it or not.

“Nitrous acid test.”—For this I use a small glass-vessel, placed upon a plate. 10 or 15 grammes of concentrated nitric acid are placed in it, and some copper-turnings added. Around this, watch-glasses are placed, containing one, or at the most two drops of the oils, and the whole is covered with a flat glass-bell. In a few minutes the oil of rosewood acquires a dark-yellow colour; the otto has nearly the same colour; whilst the oil of geranium becomes of an apple-green colour, and retains it for some time.

“This test will serve to distinguish the two oils when in a state of purity, and may even serve to recognize oil of geranium containing the otto, because of the yellow colour which it imparts to the latter; but it is evident that it cannot serve to determine the presence of the oil of geranium in the otto of roses.

“Sulphuric acid test.”—One or two drops of the oil to be tested are put into a watch-glass; the same number of drops of very concentrated sulphuric acid are added, and the two fluids mixed with a glass-rod. All the oils are rendered more or less brown by this proceeding; but—

“The otto of roses retains the purity of its odour.

“The oil of geranium acquires a strong and disagreeable odour, which is perfectly characteristic.

“The odour of the oil of rosewood is increased, and becomes somewhat unctuous. It is not, however, characteristic.

“The commercial oil of rosewood acquires an odour distinctly like that of cubebs.

“Of these three methods, that with sulphuric acid is by far the best for distinguishing the otto of roses from the oil of geranium, and for the recognition of the second in the former. The iodine test is also very certain, but it requires considerably more time. The nitrous acid test will serve to recognize the two oils when not mixed, or even to detect the

otto of roses in the oil of geranium ; but not the latter when mixed with the former.”—*Journ. de Pharm.*

OIL OF VITRIOL.—See *Sulphuric Acid*.

O P I U M.

1. Professor Soubeiran, in his “Course of Practical Pharmacy,” says :—

“Opium is the juice of the head of the poppy (*Papaver somniferum*).

“There exists no doubt regarding the source from which opium is derived, but considerable difference of opinion prevails respecting the mode of its extraction from the poppy : some writers maintain that the opium is extracted entirely by means of incisions made into the ripe poppy-heads ; others assert that to the juice thus obtained by exudation is added that obtained subsequently by subjecting the heads to the action of the press, and even the extract furnished by the decoction of the heads in water. No doubt different processes of extraction are adopted respectively in every locality, and this circumstance, joined to the effect resulting from difference of climate and soil, fully explains the dissimilarity which we observe between the various sorts of opium of commerce. So considerable are these differences, that some sorts of opium are inferior to others in medicinal properties in the ratio of one to three.

“In the European market we distinguish three sorts of opium, viz. :—

Smyrna opium,

Opium of Constantinople,

Opium of Egypt or Alexandria.

SMYRNA OPIUM.

“This sort comes into the market in soft lumps, of greater or less bulk; the surface of these lumps is covered with numerous rumex seeds. They are light-coloured inside, but upon exposing the broken or cut surfaces to the air they acquire a dark colour. The smell of Smyrna opium is strong, and indicative of the venomous properties of the substance. The taste is bitter and acrid. This is the best sort of opium; it contains 6.9 per cent. of morphia.

OPIUM OF CONSTANTINOPLE.

“This sort is brought into the market in regular flat loaves or cakes, covered with a poppy leaf. It is drier than the Smyrna opium, and frequently even brittle. It gets soft in the hand, and furnishes a light-coloured paste, which turns brown in the air. It smells like the Smyrna variety, but its odour is somewhat less marked than that of the latter. It contains 5 to 6 per cent. of morphia.

OPIUM OF EGYPT OR ALEXANDRIA.

“This is the worst species of opium. It comes into the market in small, very dry, and very flat loaves, exceedingly clean at the surface, and retaining hardly a trace of the leaves in which they were originally enveloped. Its colour is dark-brown; its fracture is clean and shining. It has a very feeble smell, and contains only 3 to 4 per cent. of morphia.

“To these three principal species we might add the India opium, which, according to Dr. Thomson, contains three times less morphia than the Smyrna variety.

“Opium has been analyzed by a great many chemists, but more particularly by Seguin, Derosne, Sertuerner, Robiquet, Pelletier, and Couerbe.

“It contains :—

Morphine.	Thebaine, or paramorphine.
Codeïne.	Meconine.
Narcotine.	Narceïne.
Meconic acid.	Bassorin.
A brown extractive acid.	Gum.
Resin.	Caoutchouc.
Fatty oil.	Lignin.
A volatile poisonous principle.	

and, no doubt, also vegetable albumen.

“The morphine, codeine, and a portion of the narcotine exist in the opium as saline compounds soluble in water. It is generally assumed that they are combined with the meconic acid, and in part with sulphuric acid; perhaps they form also other combinations.

“Three of the constituent principles of opium are alkaline, namely: morphine, codeine, and narcotine; four are acid namely: meconic acid, the brown extractive acid, the resin, and the fatty oil. The remaining ingredients are neutral.

“The larger portion of the narcotine does not exist in the saline state in the opium, since it may be removed by simply treating the opium with ether.

“M. Pelletier has extracted from some sorts of opium another substance, to which he has given the name of *pseudo-morphine*.

“Notwithstanding the numerous investigations and the careful study of which opium has been the subject, there prevails still considerable doubt and uncertainty regarding the exact composition of this vegetable product. That morphine is the principal agent in the production of the medicinal effects of opium admits of no doubt; but we are not quite positive yet whether or not the narcotine and codeine contribute to the medicinal action of the substance. We know from the results of certain experiments that meconine, narceine, and thebaine are in the isolated state without

medicinal action ; but we cannot say whether these principles may not exercise a certain action notwithstanding, when in combination with the other matters with which they are associated in the opium. Moreover, it is still a matter of doubt whether all the substances which the chemist has extracted from opium actually exist in that vegetable product, or whether some of them may not have been formed under the influence of the agents used to effect their extraction.

“However, there are some well-ascertained facts which, although not of a nature to give us a positive insight into the various modifications which opium may suffer respectively by the different methods and processes to which it is subjected in the pharmaceutical laboratory, will yet throw some light upon these modifications, and may, accordingly, be turned to account in the respective appreciation of the several pharmaceutical preparations of that substance.

“As we have already seen, the various sorts of opium of commerce, namely, the opium of Smyrna, that of Constantinople, and that of Egypt, contain, respectively, very different proportions of morphine. The Smyrna opium, which is the best of all, containing, as it does, from 16 to 24 grammes of morphine per kilogramme, should, therefore, alone be used by the apothecary.

“Cold water extracts from opium the whole of its soluble principles, namely, the natural salts of morphine and codeine, the brown extractive acid, and the gum ; a portion of the narcotine, narceïne, meconine, thebaine, fatty oil, and resin, are equally dissolved under the influence of the soluble principles.

“Boiling water dissolves a larger proportion of the resinous matter than cold water. Infusion of opium is sometimes used externally to combat pain.”

2. Opium is more soluble in brandy than in water, and in alcohol alone. It is also partially soluble in ether, lemon-juice, and vinegar. Triturated in boiling water, $\frac{5}{12}$ th of its

weight are dissolved, $\frac{1}{2}$ or $\frac{6}{12}$ ths remain suspended in the liquor, and $\frac{1}{12}$ th remains undissolved. Its specific gravity is 1.336.

3. Whether it be owing to a difference in the modes of preparing opium, or to the substances which are purposely mixed with it, the composition of that substance is exceedingly variable.

4. Opium is often met with in commerce from which the morphine has been extracted; on the other hand, this valuable drug is often found adulterated with *starch, water, Spanish liquorice, lactucarium, extract of poppy leaves, of glaucium luteum, and other vegetable extracts, mucilage of gum tragacanth, or other gums, clay, sand, gravel*; often the opium is mixed in Asia and Egypt, when fresh and soft, with finely-bruised grapes from which the stones have been removed; sometimes also, a mixture, fabricated by bruising the exterior skins of the capsules and stalks of the poppy, together with the white of eggs, in a stone mortar, is added in certain proportions to the opium. In fact this most valuable drug, certainly one of the most important and most frequently used in medicine, is also one of the most extensively adulterated.

METHODS OF TESTING OPIUM.

5. *Estimation of the water.*—The quantity of water contained in opium may be approximatively estimated by expert persons from the consistence of the drug, but more accurately by weighing a given quantity of the opium under examination, and drying it at a steam heat until it no longer suffers any diminution in weight; the loss indicates the proportion of water.

6. *Estimation of the morphine.*—The separation of the morphine contained in opium may be effected in various ways.

7. *Robiquet's process.*—Make an aqueous extract of the opium to be examined, in the following manner:—cut the

opium in slices, and let them macerate for 12 hours in six times their weight of water, so that they may become soft; triturate the whole well, and let it stand at rest for 12 hours more; filter through linen, squeeze the residue on the filter, remove it from the filter, and subject it to the same treatment again with a fresh quantity of water. The liquor strained in the first and second operation should then be mixed together, and evaporated to the consistence of an extract. Redissolve this extract in water, and concentrate the solution. To this concentrated solution add a small quantity of magnesia (10 grains of magnesia per lb. of opium are sufficient), and boil the whole for about one quarter of an hour. This produces a rather considerable deposit of a greyish colour, which consists of free magnesia, of basic meconate of magnesia, of morphine, of narcotine, and of colouring matter. Filter and wash the precipitate with cold water, and macerate it in weak alcohol, *but without boiling*, for morphine is soluble in hot alcohol. This removes a great proportion of the colouring matter, and the narcotic acid, with a very small quantity of morphine. The liquor is filtered again, and the deposit is washed with a little cold alcohol, squeezed, dried, and finally boiled several times with fresh portions of pure or anhydrous alcohol, until this menstruum no longer dissolves anything; the liquors are evaporated, and in cooling the morphine is deposited in almost colourless crystals. By re-crystallizing it, it may be obtained quite white. The morphine obtained by this process, however, is very far from being pure; it retains a considerable proportion of narcotine.

8. *Thibouméry's process*.—Prepare an extract of opium, as above described, and dissolve it in water; add a large excess of ammonia to the boiling solution, and when cold, filter it; the precipitate collected on the filter should now be thoroughly washed thereon with cold water, and then dried. The dry precipitate must next be boiled with alcohol, sp. gr. 0.84, acetic acid is then added gradually, drop by drop, to

the liquor, until it begins to turn red ; it is filtered, and the liquor which now holds the morphine and narcotine in solution is precipitated by ammonia ; the precipitate is morphine. By this process one pound of pure opium yields 10 drachms of morphine, which does not require purification.

9. The following process may also be employed :—

10. Take 25 grammes (about 386 grains) of opium, cut it into very thin slices, and macerate it in 150 grammes (about $5\frac{1}{4}$ fluid ounces) of pure water for 24 hours. Then triturate in a mortar, and pour on a filter the divided parts which the liquid holds in suspension ; add more water to the residue, again triturate, and pour it on the same filter. Wash with distilled water until the liquid passes colourless ; add to the filtered solution an excess of well hydrated lime, boil for about five minutes ; filter and acidify the filtered solution with hydrochloric acid, which saturates the lime and combines with the morphine. The morphine is to be precipitated by ammonia, expelling any excess of the latter by ebullition. The morphine is to be collected on a filter, washed with dilute spirit, and then dissolved in boiling rectified spirit ; it crystallizes on cooling. To separate the narcotine, it must be washed with ether. The morphine is then dried and weighed. Good opium should yield 10 per cent. of morphine.—(See *Acar on Medicinal Substances.*)

11. *M. Guilliermont*, of Lyons, lately proposed (*Comptes rendus*) the following method of testing opium :—

12. Take 200 grains of the opium to be tested, cut it in slices, and triturate it in a mortar with four times its weight of alcohol, strain it through linen, squeeze the residue, and pour upon it about 300 grains more of fresh alcohol ; mix the strained liquor together in a wide-mouth bottle, and add thereto 60 grains of ammonia. In the course of 12 hours the morphine will be spontaneously separated, accompanied by more or less narcotine, the morphine covering the interior of the vessel with coloured, large, and gritty crystals, feeling like sand, the narcotine crystallizing in very light, small,

white, and pearly needles. Wash these crystals with water, either through a paper-filter or linen, to free them from the meconate of ammonia which they contain; after which the narcotine may be separated from the morphine by decantation in water, which will remove the narcotine, which is lighter. But, according to M. Mialhe, the morphine is more effectually separated by washing the crystals with 60 or 70 grains of ether, morphine being insoluble in that menstruum; this is done by triturating the pulverized crystals with the ether, the morphine is left in an insoluble state; it may then be dried and weighed.

13. The distinctive characters of morphine and narcotine are as follows :—

MORPHINE.

Ordinarily white, opaque, shining, in prismatic, rectangular needles, or in prisms with a trapezoidal base; or when obtained by precipitation by ammonia, it is in curdy flakes, which sometimes coalesce into a crystalline powder.

NARCOTINE.

When recently precipitated light, white, crystalline flakes, or in colourless, silky, rhombic prisms, generally more bulky than those of morphine.

Water.

It has a *bitter* taste, yet it is slight, on account of its being very sparingly soluble in cold water, but it is more soluble in boiling water.

Altogether insoluble in water, and nearly so in boiling water, therefore the precipitate is *tasteless*.

Alcohol.

90 parts of cold and 20 to 30 parts of boiling alcohol dissolve one of morphine.

100 parts of cold and 24 of boiling alcohol dissolve one of narcotine.

Ether.

Insoluble.

Very soluble, especially with the help of heat.

MORPHINE.

NARCOTINE.

Potash, Soda, Ammonia.

In solutions of morphine, white crystalline precipitate, very *readily soluble* in excess of potash, and also in ammonia, but less readily, and on evaporating the ammonia the morphine separates again. The precipitate is likewise soluble in solution of sal ammoniac.

In solution of narcotine, white pulverulent precipitate *insoluble* in an excess. If the liquor precipitated by ammonia be mixed with ether, the precipitate is re-dissolved.

Carbonate of Potash or of Soda.

White, crystalline precipitate insoluble in excess.

White, pulverulent precipitate insoluble in excess.

Bicarbonate of Potash or of Soda.

White, crystalline precipitate, in neutral solutions, insoluble in excess; if the solution of morphine be acid and cold, no precipitate is produced.

White pulverulent precipitate insoluble in excess.

Nitric Acid (aqua fortis).

Poured upon the precipitate, imparts to it a reddish-orange colour, which soon becomes yellow. (Strychnine and brucine present the same reaction).

Dissolved, but not coloured. Concentrated nitric acid with the help of heat, gives it a yellow colour.

Sulphuric Acid.

Dissolved but not coloured.

Dissolved into a yellow liquid, which turns brown by applying heat, but if the sulphuric acid contains even as small a quantity as $\frac{1}{1000}$ of nitric acid, the liquor assumes an intense blood red colour in the course of seven or eight minutes, which, however, disappears by a further addition of nitric acid.

MORPHINE.

NARCOTINE.

Neutral perchloride of Iron.

Or generally any persalt of iron ; Nothing.

the precipitate assumes a fine dark-blue colour, which disappears by adding an excess of acid, but which is reproduced by saturating this excess of acid by an alkali. This colour is destroyed also by heat, by alcohol, and by acetic ether, but not by sulphuric ether.

Iodic Acid.

Even very dilute, added to the Nothing.

precipitate of morphine, is decomposed, and the precipitate becomes brown, which is due to a separation of iodine, which may be identified as such by a cold solution of starch, which immediately turns blue.

Perchloride of Gold.

Produces in solution of morphine Nothing.

a flocculent brownish precipitate, which produces a green liquor when dissolved in hydrochloric acid.

Reddened litmus paper, and turmeric paper.

The first is rendered *blue* again, Nothing.

and the second *brown*, by the solution of morphine.

14. As meconic acid is always a constituent of opium, small quantities of opium, according to M. Hare, may be detected

in aqueous solutions, for example, ten drops in half a gallon, by adding a few drops of acetate of lead to the liquor, a portion of which has been previously poured into a conical glass. This produces a meconate of lead, which however requires some time to fall down (from six to twelve hours), and the liquor should be stirred from time to time, in order to agglomerate the precipitate. When the precipitate has thus settled at the bottom of the glass, the supernatant liquor is decanted, and about thirty drops of sulphuric acid, and an equal quantity of persulphate of iron are then poured on the meconate of lead. The sulphuric acid decomposes the meconate of lead which produces sulphate of lead, whilst the liberated meconic acid, reacting upon the persalt of iron, imparts a beautiful red colour to the mixture. This colour is similar to that produced by hydrosulphocyanic acid with persalts of iron.

ORPIMENT.—See *Sulphuret of Arsenic*.

OXALIC ACID.

1. Oxalic acid exists in the juice of several plants in the free state, but more generally combined with lime and potash, but it is always artificially obtained by treating sugar or molasses with nitric acid.

2. Oxalic acid is in prismatic, quadrangular, oblong, transparent crystals, they are inodorous, but have a very acid taste. They are soluble in water and in alcohol, especially with the help of heat. The crystals in dissolving in water produce a pretty sharp cracking noise, which may serve to identify them. When heated to 212° Fahr. they fuse in their water of crystallization, they are volatilized without residuum, and

are partially decomposed by a stronger heat. Exposed to the air at a temperature of about 100° , they effloresce and fall to powder.

3. The oxalic acid of commerce generally retains traces of nitric or of nitrous acids, and is often adulterated with sulphate of magnesia.

4. The presence of *nitric* or of *nitrous* acid is detected by dissolving the crystals or the powder (if in that state,) in water, adding a few drops of solution of sulphate of indigo, and boiling the whole; when, if nitric acid be present, the blue colour will be destroyed. The presence of these acids may sometimes be detected at once in oxalic acid by the smell, and also by the yellow colour and corroded state of the corks of the bottles in which it is ordinarily kept. These acids may be removed by dissolving and recrystallizing the oxalic acid.

5. The presence of organic substances in oxalic acid may be detected in the same manner as in binoxalate of potash by sulphuric acid. (See *Binoxalate of Potash*.)

6. The presence of *soluble sulphates*, such as sulphate of magnesia, is detected by dissolving a given weight of the oxalic acid in a pretty large quantity of water, the solution should be strongly acidified with hydrochloric acid, and then tested with solution of chloride of barium, which should be collected on a filter, washed, dried, ignited and weighed. 117 of sulphate of baryta represent 40 of sulphuric acid, and consequently one equivalent of any sulphate.

7. Pure oxalic acid, heated to redness upon a piece of platinum foil, should evaporate entirely.

8. The best method of estimating the real quantity of oxalic acid is by treating it with an excess of peroxyde of manganese and sulphuric acid, in Drs. Fresenius and Wills' apparatus, described in the article on Acidimetry. Every equivalent of oxalic acid ($= 46$ grains) yielding two equivalents ($= 44$ grains) of carbonic acid. The peroxyde of manganese employed need not be pure, but it must, of course,

contain no carbonates. The particulars of the operation have been described in the article on Manganese, to which the reader is referred. The oxalic acid should be slightly supersaturated with ammonia. 11 parts of peroxyde of manganese are required for nine parts of oxalic acid, but the operator should put it in excess, since it does not interfere with the accuracy of the process. The balance used must be delicate enough to turn with a small weight when heavily laden.

9. Oxalic acid should always be chosen perfectly colourless, dry, without the slightest odour, and in crystals as large as possible.

OXYDE OF COBALT.

1. Oxyde of cobalt is an article in somewhat extensive demand in the potteries, and employed likewise by enamellers and glass-makers, who mix it in various proportions, either alone or in conjunction with other materials, for giving a blue colour to their wares.

2. There are two kinds of oxydes used, the peroxyde or sesquioxide, which is black when perfectly dry; the protoxyde which, when perfectly dry, has a slate colour with a slight bronze hue; this latter oxyde is that principally and almost exclusively used in the potteries; the black oxyde being unfitted for printing, on account of its soiling the copper plates, and also because it has less strength, that is to say, bulk for bulk it gives less colour.

3. Both oxydes are often contaminated by variable proportions of oxyde of nickel, of peroxyde of iron, copper, lead, zinc, antimony, bismuth, alumina, silica, arsenic, magnesia, and lime. I have examined samples of oxyde of cobalt represented as *pure*, and which contained no less than 72 per cent. of impurities!

4. The presence of these foreign substances may be detected as follows:—

5. The oxyde of cobalt under examination, 50 grains for example, is first dissolved in hydrochloric acid which produces a strong disengagement of chlorine; the solution should be of the deepest pink colour, if the oxyde is pure; or if concentrated acid has been employed, the solution should have a beautiful blue colour. If the dilute solution, instead of being of a beautiful deep pink colour, has the slightest tinge of orange, the presence of oxyde of copper, of nickel, or of peroxyde of iron is certain; and if the concentrated acid solution, instead of being of a pure blue colour, is green, the presence of nickel, or of iron, or of both, is also certain. A very trifling proportion of these impurities totally unfit the oxyde of cobalt for many delicate purposes, and is absolutely objected to by the English buyer. These solutions, even when full of impurities to an enormous extent, but largely diluted with water, always appear of a good bright pink colour, which simulate that produced by the pure oxyde diluted to the same extent.

6. After treatment with hydrochloric acid, if a sediment is left, it is generally silica, or peroxyde of iron, or both; the liquor need not be evaporated to dryness to detect these impurities, which at once remain undissolved by the acid.

7. Separate the silica and peroxyde of iron left in an insoluble state by filtering, and pass a stream of sulphuretted hydrogen through it. If this produce at once a black precipitate, it is owing to the presence of copper, or lead merely; the precipitate, however, is often mixed with brown and yellow particles more or less abundant, and which are due to the presence of antimony, bismuth, or arsenic, which are thus precipitated as sulphurets. If no lead or copper is present, and the precipitate produced by sulphuretted hydrogen is yellow, it is sulphuret of arsenic; if orange red, it is antimony. The precipitate, however, has frequently a brownish tinge, in which case it consists generally of sulphuret of arsenic mixed with some antimony or bismuth, or with both these two metals. The liquor, which should smell strongly

of sulphuretted hydrogen, should be left at rest in a warm place for about twelve hours, after which it should be filtered. The liquor filtered from the precipitates should then be boiled until all odour of sulphuretted hydrogen has disappeared, and nitric acid is then poured in, the boiling is resumed for a few minutes, and it is filtered. The filtered liquor must now be supersaturated with ammonia, and hydro-sulphuret of ammonia being added, collect the black precipitate so produced on a filter, and wash it well with water containing a little hydrosulphuret of ammonia. Keep the liquor filtered therefrom for further examination. The black precipitate on the filter, and which is sulphuret of cobalt, mixed perhaps with sulphuret of nickel, of iron, and also with alumina, is treated by nitric acid, and boiled until the sulphur of the sulphurets has agglomerated into perfectly yellow lumps ; filter, and to the filtered liquor add a pretty large quantity of sal ammoniac, and likewise an excess of ammonia. If iron, or alumina, or both are present, a precipitate will be produced which is reddish-brown when iron, either alone or mixed with alumina, is present, and white when the solution contains alumina only. This precipitate is collected on a filter, and re-dissolved by hydrochloric acid, the hydrochloric acid solution is re-precipitated by ammonia. It is necessary thus to re-dissolve the precipitate first produced by ammonia, because a considerable quantity of oxyde of cobalt falls with it, and would therefore give an incorrect result. The reddish-brown precipitate should now be boiled with caustic potash, in order to dissolve any alumina which may be mixed with the *peroxyde of iron*, which is then collected on a filter, and the liquor filtered therefrom being first supersaturated with hydrochloric acid, is boiled with an excess of ammonia, which will produce a white precipitate of *alumina*, if that earth was present.

8. The liquid filtered from the precipitate produced by ammonia in the nitric acid solution contains not only the oxyde of cobalt, but also oxyde of nickel and of zinc, if these substances exist in the article under examination.

9. Add therefore hydrosulphuret of ammonia to the pink or red liquor; this will precipitate these three oxydes in the state of sulphurets, which should be washed with water, and redissolved in *aqua regia*, boiling the whole until the sulphur of the decomposed sulphurets has agglomerated into yellow lumps, and filter. To the filtered liquor add a considerable excess of caustic potash, and boil. This will precipitate the cobalt and the nickel, whilst the oxyde of zinc will be kept in solution. The precipitate is collected on a filter, and the filtered liquor which is strongly alkaline, is tested by hydrosulphuret of ammonia, which will produce a white precipitate of sulphuret of zinc, if that metal is present. It should be observed that zinc cannot be entirely separated by potash, and that a certain quantity is always retained by the precipitated cobalt and nickel. The precipitate produced by potash, and which consists of cobalt, and possibly of nickel, should be washed with boiling water, redissolved in hydrochloric acid, and a large quantity of a clear solution of chloride of lime being poured into it, the whole is transferred to a large glass-jar, of such capacity that one fourth of it may remain empty, it is then tightly corked up and left for twenty-four hours at rest. A black precipitate will be formed; but if nickel is present, the supernatant liquor is green, and on decanting it, and testing with ammonia, the characteristic blue colour, indicative of the presence of nickel, is produced.

10. The liquor filtered from the precipitate produced by hydrosulphuret of ammonia in the first instance, which was put aside for further examination, and which may contain magnesia and lime, should be supersaturated with hydrochloric acid, and boiled until all odour of sulphuretted hydrogen has disappeared. It is then filtered, and the filtrate is boiled with an excess of carbonate of ammonia mixed with ammonia. If after boiling for some time a precipitate is produced, it is an earthy carbonate which should be separated by filtering, and if the filtrate, being tested with

solution of phosphate of soda, produces a white precipitate, it is owing to the presence of magnesia.

11. Oxyde of cobalt, which contains more than 2 per cent. of impurities, is perfectly unsaleable in this country, in the potteries, except for certain very limited purposes. (See *Cobalt Ore*, page 195.)

OXYDE OF ZINC.

LANA PHILOSOPHICA. POMPHOLIX. FLOWERS OF ZINC.
NIHIL ALBUM. WHITE ZINC.

1. Oxyde of zinc has a beautiful white colour, and is a combination of oxygen with zinc or spelter (ZnO), which cannot be decomposed by heat alone. It absorbs carbonic acid from the air, and when it has been left exposed for a long time, it accordingly effervesces when treated by acids; wherefore the effervescence produced, when thus tested, with a view of ascertaining its purity, should not always be taken as indicative of the presence of earthy carbonates.

2. This oxyde has lately been employed as a substitute for white lead, and there is no doubt but that it possesses many advantages over the latter substance as a pigment. Pure oxyde of zinc has a silver white colour of great brilliancy, so much so, that the best white lead looks murky by the side of it; it has, moreover, the great advantage of not being poisonous, and, when mixed with oil, it has not the unpleasant smell of white lead paint. Its *covering* power is, however, inferior to that of white lead, in the proportion of about 1 : 3, hence its employ will probably be reduced to such works where superiority of colour is of more importance than economy. It is asserted, that by mixing it with 15 or 16 per cent. of its weight of linseed oil, previously heated, with peroxyde of manganese, that it covers as well as white lead. However this may be, it should be borne in mind, that the colour of oxyde of zinc not being affected by sulphuretted hydrogen, it will endure much longer than white

lead paint, and this, to some considerable extent, should be looked upon as a set off against its greater original cost.

3. Commercial oxyde of zinc is sometimes adulterated with *starch*, *chalk*, *carbonate of magnesia*, *of baryta*, *of zinc*, and *white clay*.

4. The presence of these substances may be detected in the following manner :—

5. Boil a portion of the oxyde of zinc under examination in water, and when the liquor has become perfectly cold, pour into it a little of an aqueous solution of iodine ; if a blue colour is produced, the presence of *starch* is certain.

6. Dissolve another portion of the oxyde of zinc in question in acetic acid ; if an effervescence takes place, the presence of an earthy carbonate may be suspected, which may be afterwards identified ; the alumina, if any be present, will remain insoluble, or if a portion of it is taken up, it will be detected subsequently in the liquor. The acetic acid solution should now be treated by a current of sulphuretted hydrogen, which will precipitate all the zinc in the state of sulphuret of zinc, which should be left at rest, until it has settled well, after which the supernatant liquor is decanted, and the precipitate is collected on a filter. The liquor filtered from the sulphuret of zinc should be concentrated by heat, sulphuric acid and alcohol, being now added, will precipitate the *lime*, if present, in the state of sulphate of lime, which may be collected on a filter, washed with spirits of wine, dried, ignited, and weighed. 68 grains of sulphate of lime represent 28 grains of lime, or 50 grains of carbonate of lime ; or each grain of sulphate of lime contains 0.41176 of lime.

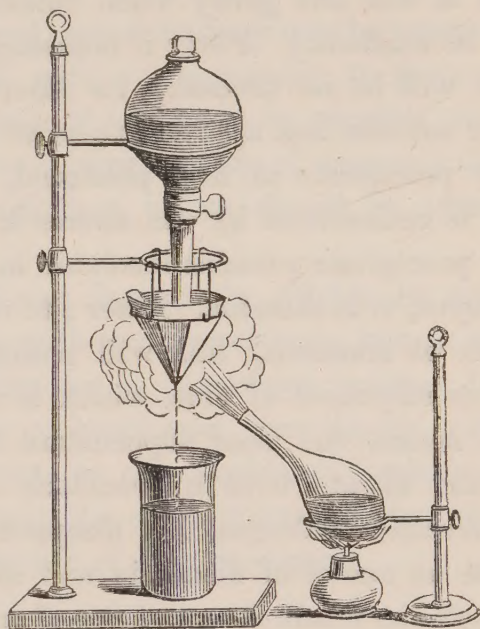
7. Lime may also be precipitated by boiling the liquor filtered from the sulphuret of zinc, until all odour of sulphuretted hydrogen has disappeared, filtering if necessary, adding a suitable proportion of sal ammoniac, in order to keep the magnesia, if any be present, in solution, saturating the free acid with ammonia, and then adding oxalate of am-

monia, which will precipitate the lime in the state of oxalate of lime, which should be collected, and washed on the filter, dried, and ignited in a platinum crucible. The oxalate burns with a blue flame, due to the oxyde of carbon produced ; it should be calcined until it is quite white, yet the heat must not be too strong. The residuum consists of carbonate of lime, from which, after weighing, the quantity of lime is calculated. 1 grain of carbonate of lime contains 0.56292 grain of lime.

8. If, however, the lime has been separated, as sulphate of lime, the liquor filtered from it should be exposed for several hours to a moderate heat in order to expel the alcohol, and the *magnesia*, if any be present, is precipitated as bibasic phosphate of ammonia and magnesia, by solution of phosphate of soda with addition of ammonia. But when the lime has been precipitated by oxalate of lime, the filtrate may at once be treated by phosphate of soda, as just said. The double phosphate of ammonia and magnesia takes a long time to settle, and as it is not quite insoluble in water, it should not be washed too long on the filter, otherwise the water used for washing will pass turbid ; it is, however, better to wash it with water mixed with one-eighth of ammonia. The precipitate after washing is well dried and ignited at a moderate temperature at first, which is gradually increased to a good white heat. The residuum is pyrophosphate of magnesia, which, when cooled, may be weighed. 1 grain of it represents 0.36637 grain of magnesia.

9. Magnesia may also be precipitated from the liquor filtered from the sulphate of lime, provided no other earth is present, by means of a solution of carbonate of potash and boiling the whole for some time. The precipitated neutral carbonate of magnesia produced is then collected on a filter, washed without interruption, with boiling water, and only for a moderate length of time, because it is not quite insoluble in water, after which it is dried, ignited, and weighed.

10. The water used for washing should be as hot as possible, because carbonate of magnesia is less soluble in hot than in cold water. For which purpose I am in the habit of pouring hot water in a separating funnel, and directing a stream of steam issuing from a Florence flask on the outside of the filter containing the precipitate, and which is placed in my platinum-wire filter-holder as here represented. I beg to recommend this apparatus for filtering in all cases where hot water is not objectionable, which is seldom the case, the filtering proceeding then with tenfold rapidity.



11. The presence of *alumina* is always very easily detected by dissolving the oxyde of zinc under examination in either acetic or hydrochloric acid, adding a sufficient quantity of sal ammoniac, and then a large excess of ammonia, which will precipitate the alumina, which may be collected on a filter, washed, dried, ignited, and weighed. The lime and magnesia might also be separated from the liquor filtered from the alumina, in the manner which has been described before.

12. Let us suppose, however, that the sample under examination contains besides oxyde of zinc, alumina, or baryta, or lime, or magnesia, or all these substances, the most ready course to be adopted for the detection of these substances should be as follows :—

13. Dissolve the sample in moderately dilute hydrochloric acid. (No sediment should be left. If any appears it may be silica, possibly oxyde of *lead*; in the latter case, a drop of hydrosulphuret of ammonia will render it black, and if it is silica it will feel gritty when rubbed with a glass rod, or it may be alumina.) Filter if necessary, (if the oxyde is pure there will be no necessity for filtering), add sal ammoniac to the solution and a large excess of caustic ammonia. The bulky precipitate at first produced, and which is oxyde of zinc, is redissolved by the excess of ammonia. If a white flaky precipitate remains insoluble in the excess of ammonia employed, it is alumina. Filter; to the filtrate add hydrosulphuret of ammonia, this will precipitate the whole of the zinc as sulphuret of zinc, which is white, allow it to settle well, decant the clear supernatant liquor into a filter, and boil the filtrate with hydrochloric acid until all odour of sulphuretted hydrogen has disappeared; filter; add to the filtrate an excess of ammonia and of carbonate of ammonia, and boil the whole for a quarter of an hour. If a precipitate is formed, it is an earthy carbonate, carbonate of lime or of baryta; collect them on a filter, wash, and redissolve them in hydrochloric acid; test a portion of this solution with one of sulphate of lime; if a precipitate is produced, baryta is present. Take another portion of the same solution, dilute it with water, saturate exactly the free acid with ammonia, and then add oxalate of ammonia. If a white precipitate is produced, *lime* is present. The liquor which was filtered from the earthy carbonates precipitated by carbonate of ammonia may now be tested with phosphate of soda; if a precipitate is produced, it is due to the presence of magnesia.

14. If lime and baryta having been found in the oxyde of zinc under examination, the operator should wish to estimate their respective quantity, he should after having separated the zinc from its solution in acetic acid, as before mentioned, by means of sulphuretted hydrogen, dilute the liquor with water, and add thereto some very dilute sulphuric acid, as

long as a precipitate is produced, it is sulphate of baryta, which should be allowed to settle completely ; it should then be collected on a filter, washed, dried, ignited and weighed ; each grain of sulphate of baryta represents 0.65632 grain of baryta.

15. The liquor filtered therefrom may now be concentrated by evaporation, mixed with sal ammoniac to prevent the precipitation of magnesia, if this earth be present, and saturated with ammonia ; on adding oxalate of ammonia the lime falls down as oxalate of lime, which should be treated as mentioned before.

16. Pure oxyde of zinc is entirely soluble in muriatic, nitric, and acetic acids, without effervescence, but, as we said before, a slight effervescence is sometimes noticed, because the pure oxyde absorbs carbonic acid from the air. A solution of nitrate of baryta, or of chloride of barium should produce no precipitate in the clear, dilute solution, or else a sulphate (probably sulphate of zinc) is present.

OXYMURIATE OF MERCURY.

See *Corrosive Sublimate*.

PACFONG.—See *German Silver*.

P A L M O I L.

1. Palm oil has the consistence of soft butter or lard, is of a deep orange-red colour, has an odour of strawberry or of violets, but somewhat rancid, it is almost tasteless. It is obtained from several species of palm trees which grow on the western coast of Africa. It is generally mixed with

detritus of branches, sand, and other impurities, and in order to estimate their amount, the easiest and most ready way is to melt the oil, to strain it, to boil the sediment with water, and strain. A better way consists in putting a portion of the oil in a small calico bag, suspended at the top of a jar by threads, or other convenient means, and to admit a stream of steam by a tube from a florence flask into the jar, which should be kept covered. The steam melts the oil, which percolates through the bag, in which the impurities are afterwards found in a perfectly clean state. They may then be dried and weighed. An approximative way of estimating the amount of these impurities, consists in putting a certain quantity of the oil in a glass tube closed at one end, and immersing it into boiling water. The oil is thus rendered fluid, and the impurities, being heavier, settle at the bottom.

2. It is stated in various books that palm oil is sometimes imitated with hog's lard, coloured with turmeric and scented with florentine iris root. It is hardly possible that such a fraud can be practised, seeing that hog's lard is double the price of genuine palm oil,

POMPHOLIX.—See *Oxyde of Zinc*.

PAPERS (COLOURED).—See *Blanc Mange*.

PEARLASH.—See *Potash*.

P E P P E R .

1. Pepper is the fruit of various kinds of plants, which grow principally in India, Java, and the eastern islands.

The following varieties are met with in commerce, namely, —black pepper, white pepper, cayenne pepper, long pepper, and cubebs.

2. *Black pepper*.—Good black pepper should have a very hot, pungent taste, and a strong aromatic odour ; the grains should be hard and not very full of wrinkles ; that which is in small shrivelled grains is of inferior quality, neither should the grains break easily when pressed between the fingers. Black pepper from Malabar is the best.

3. *White pepper* is the same substance as black pepper, from which the outer coating has been removed by blanching, it is accordingly much less pungent and strong than black pepper.

4. Both *black* and *white pepper*, when ground, are very often adulterated, and sometimes in an extraordinary degree with ground *oil-cake*, *linseed-meal*, and other like substances. The best way of guarding against adulteration is, like for coffee, to buy the article in the grain, and to examine whether it has the appearance which we have described above, and which are the criteria of a good quality.

5. MM. Bussy, and Boutron-Charlard, “*Traité des moyens de reconnoître les Falsifications des Drogues simples et Composées*,” describe a falsification of the grains of pepper, by *manufacturing* them with cayenne-pepper, mustard, and various acrid and pungent powders made into a paste with mucilage, and granulated in such a way as to bear considerable resemblance with genuine pepper, and scarcely recognizable when mixed with a suitable quantity of the latter. They state that the manufacturer, in order to imitate the genuine article more closely still, introduces into the interior of the false grains a mustard seed as a kernel to the above paste, so that on breaking the artificial grain, the mustard seed, which has become loose by drying, falls out, and simulates exactly the little hollow which is generally seen in the centre of the genuine grains. The best way of detecting this fraud, consists in throwing a certain quantity

of the suspected pepper into tepid water ; the genuine pepper remains solid and retains its spherical shape, whilst the spurious grains swell out, soon become soft and gluey, and on stirring become disintegrated and fall into powder.

6. For the purpose of ascertaining whether ground pepper is genuine and of good quality, the best way consists in ascertaining the amount of piperine contained in the pepper under examination. This may be done by treating 1000 grains, for example, of pulverized pepper, with alcohol of sp. gr. 0.833, until they are exhausted. The solution is then distilled to the consistence of an extract ; the extract so obtained is then mixed with a solution of caustic potash, which dissolves the rosin, and leaves a green powder, which should be first well washed with water, and then dissolved in alcohol of sp. gr. 0.833. By spontaneous evaporation the solution yields quadrilateral transparent obliquely-truncated crystals of piperine, which are tasteless and inodorous, insoluble in cold water, sparingly soluble in boiling water, from which they separate on cooling ; soluble in alcohol, especially with the help of heat. The alcoholic solution is precipitated by water. Good pepper yields about one and a half per cent. of piperine ; and, of course, if the article is adulterated, the reduced proportion of the piperine obtained may serve to indicate the quality of the pepper, or the extent of the fraud.

PEROXYDE OF MERCURY.

RED OXYDE OF MERCURY. NITRIC OXYDE OF MERCURY. PRECIPITATE PER SE.

1. Peroxyde of mercury (HgO) is ordinarily in the form of a crystalline powder of a red or orange-red colour, which becomes yellowish when reduced into very fine powder, very slightly soluble in water ; the solution renders syrup of violets green. When heated, peroxyde of mercury turns

black, but it becomes red again on cooling. At 400° it is resolved into mercury, and oxygen is evolved.

2. Peroxyde of mercury is sometimes adulterated with *red lead*, or with *brick-dust*. This fraud may be detected by heating a portion of it in a small German glass-tube, closed at one end, until the peroxyde of mercury is completely decomposed; a fused residuum of *protoxyde of lead* will then be left, or, if brick-dust is present, it will remain unaltered in the tube; or a portion of the peroxyde of mercury may be heated on charcoal before the blowpipe, when the lead or the brick-dust will be left on the charcoal, by which means the fraud may be at once detected.

PERUVIAN BARK.

1. Peruvian bark is the name of several species of bark of trees of the genus *cinchona*, found in Peru and several other parts of South America. The value of the bark may be determined as follows :—

“The bark is to be submitted, in the first place, to a preliminary examination, for the purpose of ascertaining the amount of vegeto-alkali contained in it. The surest and safest way is to take a certain quantity, say about two pounds, of the bark, and to treat this by the common process for the preparation of sulphate of quinine. A prompter, but less conclusive test, is the precipitation of a decoction of the bark by means of infusion of gallnuts; the amount of vegeto-alkali contained in the bark being estimated from the less or greater abundance of the precipitate formed. Gelatine strikes a white or greyish, tartar emetic a yellowish, precipitate in decoctions of bark. Solution of persulphate of iron colours decoction of bark green; sometimes it produces an abundant greyish-black precipitate; after the subsidence of this precipitate the supernatant liquid looks green.

“M. Guillermond, the younger, has given the following

very commodious process for testing bark :—Reduce the bark to powder, and treat this, by the method of displacement, with ten parts of alcohol of 80 cent. (31° Cartier). Add to the alcoholic product 30 grammes of pulverized quicklime for every kilogramme of bark, and agitate the mixture repeatedly ; by this operation the liquor is almost completely decolorized. Remove the calcareous precipitate by filtration, and add to the filtered liquid sulphuric acid in quantity sufficient only to impart to it the very faintest acid reaction. Distil it ; filter off the trifling quantity of resin which has precipitated, and concentrate the filtrate to crystallization. A minute quantity of sulphate of quinine remains in the mother liquor, from which it may be obtained by the appropriate process. This last operation may, however, in most instances be omitted, as the quantity of sulphate in the mother liquor is usually very minute only.

“The quantities of sulphate of quinine or sulphate of cinchonine respectively furnished by the several varieties of bark which occur in commerce, are as follows :—

“One kilogramme of Calisaya bark yields (without the rind) 32 to 34 grammes of sulphate of quinine.

“One kilogramme of Calisaya bark yields (with the rind) 24 grammes of sulphate of quinine.

“One kilogramme of grey Loxa bark yields 12 to 16 grammes of sulphate of cinchonine.

“One kilogramme of grey Lima bark yields 12 grammes of sulphate of cinchonine.

“One kilogramme of intensely red bark yields 16 grammes of sulphate of quinine, 8 grammes of sulphate of cinchonine.

“One kilogramme of pale red bark yields 12 grammes of sulphate of quinine, 8 grammes of sulphate of cinchonine.

“One kilogramme of spongy Carthagena bark yields 3 to 4 grammes of sulphate of cinchonine.”

“The sulphate of quinine is prepared mostly from the yellow or Calisaya bark.

PHOSPHATE OF SODA.

1. Phosphate of soda is in oblong rhombic crystals, or in small, white, nacreous, shining plates, which do not readily effloresce by exposure, of a slightly saline, but not bitter taste; phosphate of soda turns syrup of violets green. It is soluble in three parts of cold and two of boiling water. Its solution is precipitated by barytic salts, and the precipitate is completely soluble, without effervescence, in nitric acid.

2. The salts by which phosphate of soda is generally contaminated are *sulphate* or *carbonate of soda*, *chloride of sodium*, and sometimes a little *arsenic* or *arsenious acid*.

3. The presence of *sulphate of soda* is detected by dissolving a portion of the salt in distilled water, and acidifying it with nitric or hydrochloric acid. If a solution of chloride of barium, or of nitrate of baryta being now added, produces a white precipitate, *insoluble in water and in acids*, it is sulphate of baryta; the liquor containing the precipitate should be boiled a little in order to agglomerate it, and after settling, it is collected on a filter, washed, dried, and ignited. 117 gr. of sulphate of baryta represent 40 of anhydrous sulphuric acid, and consequently, 172 of dry sulphate of soda; or each grain of sulphate of baryta represents 0.34368 grain of sulphuric acid.

4. The presence of *carbonate of soda*, or of any other carbonate, is detected by moistening the salt with a little water, and pouring an acid upon it, which will produce a disengagement of carbonic acid, the quantity of which may be readily estimated by Dr. Fresenius and Wills' apparatus.— (See *Alkalimetry*.)

5. The quantity of carbonate of soda in phosphate of soda, may also be estimated by carefully precipitating the solution with nitrate of baryta, collecting the precipitate, washing, drying, and then weighing it. It should then be treated by

weak nitric acid, which will re-dissolve the carbonate and phosphate of baryta, and leave any sulphate which may be present in an insoluble state; the filtrate being now saturated by ammonia, the phosphate of baryta alone will be precipitated, and after separating it by filtering, the baryta left in the solution may now be precipitated by boiling with carbonate of ammonia; each grain of carbonate of baryta thus precipitated corresponds to 0.545 grain of carbonate of soda. If a solution of carbonate of soda being added to one of phosphate of soda renders it turbid, it is a proof of the presence of an earthy base.

6. The presence of *chloride of sodium* is recognized by dissolving a portion of the phosphate of soda under examination in water, acidifying the solution with nitric acid, and testing with solution of nitrate of silver, which will then produce a precipitate of chloride of silver, insoluble in dilute acids, but immediately soluble in ammonia.

7. *Arsenic* and arsenious acids, which exist sometimes in phosphate of soda, may be detected by dissolving the phosphate, adding hydrochloric acid to the solution, and passing a current of sulphuretted hydrogen through; a yellow precipitate of sulphuret of arsenic is produced, especially by applying heat; if the solution thus saturated with the gas be left at rest for about 12 hours, in a warm place, the whole of the arsenic will be precipitated.

PINCHBECK.—See *Brass*.

PLATINUM.

ORES OF PLATINUM.

1. Platinum ore is found in the sandy deposits which contain gold and diamond; the principal mines of this most

valuable metal are those of Choco, in New Grenada, of the Brazils, and of the Oural Mountains.

2. The ore of platinum consists chiefly of platinum, iridium, osmium, palladium, iron, copper, and a native alloy of osmium and iridium. The latter compound is harder than ruby, and has been applied to the manufacture of extremely elegant and durable pens, known under the name of "Everlasting gold pens, the invention of J. I. Hawkins, Esq., C. E."

3. The ore of platinum contains besides some chrome-iron, titanium-iron, small spangles of an alloy of gold and silver, a few particles of native iron, small fragments of hyacinth, a little mercury and sand.

4. Berzelius gives the following analysis of the ores of this mineral :—

Constituents.	Niche-Taglisk in Siberia.		Goro Blagodan in Siberia.	South America.		
	Non Magnetic	Magnetic				
Platinum	78.94	73.58	86.50	84.30	86.16	84.34
Iridium	4.97	2.35	"	1.46	1.09	2.58
Rhodium	0.86	1.15	1.15	3.46	2.16	3.13
Osmium	"	"	"	1.03	0.97	0.19
Palladium	0.28	0.30	1.10	1.06	0.35	1.66
Iron	11.04	12.98	8.32	5.31	8.03	7.52
Copper	0.70	5.20	"	0.74	0.40	"
Alloy of osmium and iridium, and foreign matter	1.96	2.30	1.40	0.72	2.01	1.87

5. The method recommended for the separation of platinum from the other metals with which it is mixed, is the following.

6. The operator first separates by the hand all the grains of the ore which have a different appearance from the rest, and these are stirred about with a good magnet, in order to separate all the magnetic pieces, and the metallic iron (native), which may exist among them. As the composition of

these magnetic grains differs from the rest, they should, if necessary, be treated separately, and at any rate, be weighed, in order to determine their amount or proportion.

7. The operator should now take 25 or 30 grains of the sample, and treat them by aqua regia, containing an excess of hydrochloric acid ; when the action of the acid appears to be exhausted, it is replaced by a fresh quantity, and so on, until the fresh acid ceases to be tinged yellow. During this treatment, fumes of nitrous and of osmic acids are evolved. When the platinum has altogether dissolved (which is best effected in a small glass-retort), dilute the solution with a small quantity of water, and leave it at rest, until it has quite settled and the liquor has become perfectly clear. The residuum consists of spangles of iridium and osmium, of a black powder, which is metallic iridium, Titan-iron, chrome-iron, or quartz.

8. The clear solution above alluded to is decanted and evaporated to pappy consistence, and if it be very acid, it should be neutralized with ammonia, so that there should be only a slight excess of acid ; a very concentrated solution of sal ammoniac is then added, and also a sufficient quantity of alcohol, which will precipitate the platinum in the state of ammonia-chloride of platinum ; and as the precipitate requires a very long time to settle, the liquor should be left at rest for twenty-four hours, after which the precipitated ammonia-chloride of platinum may be collected on a filter, and washed with spirits of wine, to which a little sal ammoniac has been added. The precipitate should then be dried, wrapped up in the filter, and put into a platinum crucible, closed with its cover. A moderate heat is then applied, during which the paper becomes charred, after which the heat is increased a little, in order to volatilize the chlorine and the ammoniacal salt ; the cover of the crucible should then be partially removed and the heat increased, in order to incinerate the charred filter in the usual way, and the spongy platinum left behind is weighed.

9. Instead of sal ammoniac, chloride of potassium, which precipitates platinum more completely still, may be employed. It is done as follows :—To the concentrated aqua regia solution, add about 60 per cent. of its bulk of alcohol ; if the solution is acid, neutralize it by solution of potash, and then add a concentrated aqueous solution of chloride of potassium. The potash-chloride of platinum so produced is allowed to settle well, and it is then washed with spirits of wine containing a little chloride of potassium ; lastly, it must be ignited in the same way as we just described. The residuum is a mixture of metallic platinum and of chloride of potassium, which should be treated by water, in order to dissolve the chloride of potassium, and the platinum left behind is finally ignited and weighed.

10 The aqua-regia solution of the ore of platinum yields, when treated by sal ammoniac, a brick-red precipitate, which, besides ammonia-chloride of platinum, contains a small quantity of ammonia-chloride of iridium. The quantity of the latter substance being in general very feeble, is ordinarily left in the platinum of commerce. The iridium, however, may be separated from the platinum by treating the mass with aqua-regia, diluted with about three times its weight of water, which does not sensibly attack the iridium, but, on the contrary, dissolves all the platinum. This solution being reprecipitated by sal ammoniac, or by chloride of potassium, as above said, yields the double chloride of platinum, of a pure yellow, or reddish-yellow colour, which after ignition, leaves perfectly pure spongy platinum.

PLUMBAGO.—See *Black Lead*.

PORTER.—See *Beer*.

POTASH.

1. The substance known under that name in commerce is the impure carbonate of potash, obtained by lexiviating the ashes of burnt plants and evaporating the ley to dryness ; the result is an impure carbonate of potash, contaminated by variable proportions of sulphate of potash, of chloride of potassium, of silica, alumina, oxyde of iron, of manganese, &c.

2. Commercial potash is in lumps of a brown colour, brick-red internally, very hard, deliquescent, and of an intensely alkaline, bitter, caustic taste. The brown colour is due to the presence of organic matter. When the potash produced, as above said, is put into a reverberatory furnace and calcined, the vegetable matter is destroyed, and the potash becomes of a bluish-white colour, and is called pearl-ash.

3. Potash and pearlash are chiefly manufactured in Russia, Poland, and America, the immense forests of those countries supplying an abundance of fuel, and consequently of ashes. Both potash and pearlash are of great importance in several manufactures. The processes by which their commercial or alkaline value can be determined have been fully detailed in our article on *Alkalimetry*.

P O T A S H.

CAUSTIC POTASH. HYDRATE OF POTASH.

1. Pure or caustic potash is obtained from the commercial potash (carbonate of potash) by dissolving one part of the latter substance in about 10 or 12 parts of water, boiling the solution in a clean iron vessel, and adding slaked lime, in small portions at a time, to the boiling solution, until on filtering a portion of it and receiving the drops in hydrochloric acid, not the slightest effervescence is observed ;

ordinarily about one part of quick lime, previously slaked, is sufficient for 2 parts of commercial potash. The solution is then allowed to subside, the clear liquor is decanted or syphoned out, and evaporated in a polished iron vessel, or better still, in a basin of pure silver, until it assumes the appearance of a syrupy mass, which concretes in cooling.

2. Caustic potash is ordinarily in flat, irregular, brittle fragments, of a grayish-white and sometimes reddish colour; when pure, they should be perfectly white; their taste is excessively caustic, and they have a slight odour of potash ley. As they are extremely deliquescent, and attract promptly the carbonic acid of the air by exposure, they should be kept in well stoppered flasks.

3. Pure or caustic potash is generally contaminated by *silica* and *alumina*, which impurities may be readily detected by dissolving a portion of the potash under examination in water, supersaturating the alkali with hydrochloric acid, evaporating to dryness, moistening the dry residuum with dilute hydrochloric acid, and then, after a little while, pouring a sufficient quantity of water upon it; the silica, if any be present, will be found in an insoluble state. It may then be collected on a filter, washed, dried, ignited, and weighed.

4. The liquor filtered from the silica being tested with carbonate of ammonia, will produce a white, flaky precipitate of *alumina*, if that earth is present. This precipitate, which is bulky, should be washed with hot water, thoroughly dried, ignited, and then weighed.

5. If the potash contains any *peroxyde of iron*, it has a brown or reddish colour, and upon dissolving it in boiling water, the peroxyde of iron is left in an insoluble state; the quantity may be determined by collecting it on a filter, washing it thoroughly with hot water, drying it perfectly, and then igniting and weighing it.

6. If a chloride (chloride of potassium) is present, it may be detected by dissolving a given weight of the potash in water, supersaturating the solution with nitric acid, and then

adding a solution of nitrate of silver, which will produce a precipitate of chloride of silver. The liquor containing it should be warmed, after which the chloride of silver may be collected on a filter, washed, dried, fused in a porcelain crucible or capsule, and weighed. 144 grains of chloride of silver represent 84 grains of chloride of potassium, or one equivalent of any other chloride.

7. Or the solution, supersaturated with nitric acid, may be tested with a solution of nitrate of silver of a known strength, as for the assay of silver (see *Silver*). Chloride of potassium is almost invariably present in the pure potash of shops.

8. If the solution filtered from the chloride of silver above mentioned, being tested with solution of chloride of barium, yields a white precipitate, insoluble in water and in acids, it is a proof of the presence of a *sulphate*; the precipitated sulphate of baryta may then be collected on a filter, washed, dried, ignited, and weighed. 117 grains of sulphate of baryta represent 40 grains of sulphuric acid, and consequently one equivalent of sulphate.

9. If a *carbonate* is present (carbonate of potash), the addition of an acid will produce an effervescence. The quantity of the carbonate may be determined either by means of Drs. Fresenius' and Wills' apparatus (see *Alkalimetry*), or else a given weight of the solution being diluted with water, a solution of chloride of barium should be added, which will then produce a precipitate of carbonate of baryta. When the precipitate has completely settled, which requires several hours, the liquid is poured on the filter, hot water is then added to the precipitate, and after having shaken it violently, it is allowed to settle again. This operation having been repeated several times, the precipitate is finally collected on a filter. The funnel must be sheltered from the contact of the air during the filtering, in order to guard against the carbonic acid of the air augmenting the quantity of the earthy carbonate produced. The precipitate should then be washed until the filtered liquor ceases to afford a precipitate

when tested with nitrate of silver, to which a little free nitric acid has been added. The carbonate of baryta on the filter is then dried, ignited, and weighed. It does not lose any carbonic acid by ignition; each grain of carbonate of baryta contains 0.22414 grain of carbonic acid, which represents therefore 0.63166 grain of carbonate of potash.

10. If both a *sulphate* and a *carbonate* are present, and a solution of chloride of barium is used, the precipitate will consist of both, sulphate and carbonate of baryta. The collective precipitate should therefore be washed, as above said, dried, and weighed, after which it should be treated by hydrochloric acid, which will dissolve the carbonate only, and leave the sulphate in an insoluble state, the weight of which being now taken will show the relative proportion of both substances, the loss from the collective weight indicating the proportion of carbonate.

11. If traces of lime are present in the potash, oxalic acid will produce a precipitate of oxalate of lime.

POTTERS' ORE.—See *Galena and Alquistox*.

POUNXA.—See *Borax*.

PRECIPITATE PER SE.—See *Peroxyde of Mercury*.

PRINCE RUPERT'S METAL.—See *Brass*.

PROTOXYDE OF LEAD.—See *Litharge*.

PROTOCHLORIDE OF MERCURY.—See *Corrosive Sublimate*.

PRUSSIAN BLUE.

1. The Prussian blue of commerce is seldom pure, it generally contains *hydrate of alumina*, or *basic salts of alumina* and *oxyde of iron*; it is also frequently adulterated with *starch*, and with *carbonate of lime*.

2. With respect to *alumina*, its presence could hardly be called an adulteration, because formerly a certain quantity was always added in order to saturate the free alkali employed in the manufacture, and the precipitated alumina does not interfere with the colour, at least to the same extent as peroxyde of iron, which would be precipitated by the alkali and give a green hue to the product. Prussian blue, however, being always prepared now with prussiate of potash, the addition of alum is perfectly unnecessary, except as a means of augmenting the weight of the pigment.

3. Prussian blue can be purified by first pulverizing it, and digesting it in dilute hydrochloric acid for about forty-eight hours, and pouring a large quantity of water upon the mass. The Prussian blue remains insoluble, whilst all the other salts with which it was mixed are taken up by the acid and remain in solution in the supernatant liquor, which should be decanted, and replaced by a fresh quantity of water, and so on, until a few drops of water on being evaporated leave no residuum. Distilled water must be used, because if common water containing bicarbonate of lime in solution were employed, a portion of the Prussian blue would be decomposed into oxyde of iron and ferrocyanuret of calcium, which, being soluble, would be washed away.

4. Prussian blue may also be purified by dissolving a given weight of it in concentrated sulphuric acid, or in hydrochloric acid, and pouring the solution, drop by drop, in a large quantity of water; the pure Prussian blue precipitates, whilst the other salts remain in solution in the water. The Prussian blue is then collected upon a filter, washed and

dried in an oven at between 212° and 230° Fahr., until it no longer diminishes in weight.

5. Prussian blue is known to contain *starch* by boiling a portion of it in water, which will then thicken into a paste.

6. The colouring power of Prussian blue may also be tested by grinding a given weight of it with twenty-five or thirty times its weight, or a larger proportion still, of white lead and oil, and comparing the colour which is thus yielded with that produced by a same weight of genuine Prussian blue treated in the same manner.

7. The characteristics of good Prussian blue are lightness, a deep, fine, blue colour, with a coppery hue; it should adhere very strongly to the tongue, and should not effervesce when treated by acids, nor thicken when boiled in water.

PRUSSATE OF POTASH.—See *Ferrocyanuret of Potassium*.

PYROLIGNOUS ACID.—See *Vinegar*.

QUICKSILVER.—See *Mercury*.

QUININE.—See *Sulphate of Quinine*.

RED LEAD.

MINIUM.

1. This substance has all the characters of a plumbate of oxyde of lead; a sample analyzed by Berzelius was found to consist of 1 equivalent of deutoxyde, and 1 equivalent of

protoxyde of lead (PbO_2 , PbO); another sample analysed by M. Longchamps gave 1 equivalent of deutoxyde of lead and 5 equivalents of protoxyde of lead (PbO_2 , 5 PbO). M. Houtou Labillardière represents its composition as being 1 equivalent of deutoxyde of lead, and 3 equivalents of protoxyde of lead (PbO_2 , 3 PbO). Lastly, M. Dumas represents it as being 2 equivalents of protoxyde of lead, and 1 equivalent of deutoxyde of lead (2 PbO , PbO_2).

2. This important article is often adulterated by *earthy substances*—such as *brick-dust*, *red ochre*, or with *colcothar*. These impurities may be easily separated, and their amount determined by boiling for some time a known weight of the red lead with sugar and water, with the addition of a small quantity of nitric acid; the deutoxyde of lead becomes thereby converted into protoxyde of lead, which dissolves in the acid, whilst the impurities remain insoluble, and may be separated by filtering, they are then washed, dried, and weighed.

3. As red lead is produced from litharge, it may contain all the impurities of the latter, namely, copper and silver. The presence of these substances in certain manufactures is very objectionable; this is especially the case with that of crystal, to which these oxydes would impart a colour. The above impurities may be detected and estimated exactly in the manner described in the article on *Litharge*, to which the reader is referred.

RED OXYDE OF MERCURY.—See *Peroxyde of Mercury*.

RED PRECIPITATE.—See *Peroxyde of Mercury*.

R H U B A R B .

1. Rhubarb is the root of a plant of which there are several varieties. According to Dr. Goebel, “that rhubarb

which is usually obtained in the druggists' and apothecaries' shops comes from China, and two species of Chinese rhubarb are known in trade. The one is termed Russian, Moskovian, or Siberian rhubarb; the other East Indian, Chinese, Danish, Dutch, &c., rhubarb. The latter is brought to Europe from Canton, by sea, in vessels of different nations, especially English; and this is the cause of the different appellations by which it is known. That such is the case, is as well known as that the Siberian or Russian rhubarb is transported to Russia via Kjachta, and sent from Moscow and St. Petersburg to other countries.

“There exists between Russia and China a commercial treaty, according to which the Chinese government is bound to send a certain quantity of rhubarb, of a particular description, to Kjachta, where it is received by officers of the Russian government; in exchange for which, on the part of Russia, a certain quantity of furs, of a peculiar quality, are transmitted to the officers of the Chinese government. This rhubarb is called Russian rhubarb.

“For the purpose of furnishing Kjachta with this rhubarb, the governors of the provinces where the rhubarb grows, publish, according to orders officially received from Pekin, a proclamation for collecting rhubarb, and contract with each of the collectors, or their factors, as to price. These factors or dealers bring the rhubarb to Kjachta, where, and after the delivery has been effected, they receive an acknowledgement of the quantity. This they hand over to their governor, and receive payment as fixed by the previous contract with him.

“The imported rhubarb is then carefully examined at Kjachta, by Russian government officers. Some of the roots, suspected not to be of the sort required, are tried with a borer, in order to ascertain their quality. The rhubarb is then freed from all foreign matter; again pared and rasped: that which has been rejected, as well as the rind and rubbish, belongs to the Chinese, who take back the rejected pieces again to China, whilst the rind and small

fragments are burnt. Thus it happens that from a given quantity of the rhubarb imported, taking, for instance, 1000 pounds, it often happens that from 2 to 300 pounds are rejected, according to the degree of care with which the same may have been previously prepared and selected.

“ At Kjachta the rhubarb is again packed, forwarded to Moscow and St. Petersburg, and there kept till sold in the warehouses of the government druggists.* At Kjachta the rhubarb is packed up in deal-chests, which are dove-tailed, glued, and planed inside, taking care to put the larger pieces of rhubarb on the outside, and to fill up the intervals with the smaller ones so closely, that it is impossible to return into the same chest, after having taken it out, that quantity of rhubarb which may have been previously packed therein. These chests are then overcast with melted pitch, and afterwards covered with raw hides turned inside out, the hairy side lying on and adhering to the pitch, so that it may be said by this manner of packing the drug is hermetically inclosed.

“ Russian rhubarb is decidedly superior to East Indian. It is sound throughout, but it is mere fiction to assert that it may be distinguished by the peculiar form of the pieces, and that each single piece is pierced with holes, as is now and then pretended. In the chests, pieces large and small, flat and round, angular, pierced, some bearing the marks of the borer, and also some perfectly free from such marks, are mixed together. They are of a yellowish-red colour, and, when broken, present the well-known beautiful red-and-white marble appearance.

“ The statement of some writers, that for the imperial court of Russia only a white species of rhubarb is used—and this, it is said, taken from *Rheum leucorrhizum*, (Pallas)—is equally unfounded. The same rhubarb as that we have just described is also used for the Imperial Court, excepting

* In Russia, every druggist practises his trade under a license from government.

that only sound and fine roots are selected, as a matter of course. The *Rheum leucorrhizum* (Pallas), which John V. Sievers discovered in the Sangorian steppes, and which he called *Rheum narum*, have also been since found there by Dr. Meyer. The root of this plant is spreading, white, and possesses an insipid slimy taste, not at all like that of rhubarb. The real rhubarb is likely to be the *Rheum australe* (Don), or *Rheum emodi* (Wallich), which grows on the Himalayan mountains.

“ East Indian rhubarb is collected in the same provinces where the Russian is obtained. The collection of rhubarb is under no restriction of the Chinese government, nor do they take any care of the rhubarb trade, which is carried on by private individuals at Canton. The proprietors of quantities of rhubarb sell them at an arbitrary price to East Indiamen, Americans, Dutchmen, Danes, &c. Of these, however, the English buy the most.

“ This East Indian rhubarb is considerably inferior in quality to the Russian ; it is an assemblage of good and bad species, which, even if they be sound and well preserved, essentially differ from the Russian from the circumstance that they are not severally selected, and pared again, as are the Russian, and by which process all foreign matter is separated from the latter, together with the last remains of the cuticular substance. East Indian rhubarb is not allowed to be imported into Russia.

“ From Russia the carefully pared and particularly selected rhubarb alone is exported ; whilst the rhubarb exported from Canton is in the same state as when brought there by the Chinese, be it of good or bad quality ; and this has given rise in Germany to the commercial terms “ half ” and “ wholly purified rhubarb.” It is not necessary to mention that the transit by sea often materially affects its quality.

“ This explanation also shows why the Russian rhubarb is better, and at the same time dearer, than the East Indian, and why it is generally preferred. Sometimes the Bucha-

rians import rhubarb by Troitzq to Russia. It is, however, of an inferior description, carelessly pared, pierced with large holes, and very light ; hence the name of Bucharian rhubarb."

2. Russian and Turkey rhubarb are identical articles, the best pieces are, as above said, in roundish lumps perforated with a hole, of a yellow colour outside, and when broken the inside has a mottled appearance. Good rhubarb should be firm, compact, and heavy ; porous pieces are bad or very inferior. The Chinese rhubarb is in flat pieces, seldom perforated, and its taste and odour are stronger than the other. It is also heavier, and when pulverized the powder is redder than that of the Russian rhubarb.

3. Rhubarb in the lump may be of bad quality, but is not subject to adulteration ; this is not the case, however, when pulverized, for the powder is often mixed with gamboge. This sophistication may be readily detected by digesting a portion of the powder in ether, and pouring a few drops of the solution in water. If gamboge is present, a film of an opaque yellow colour will be observed floating on the surface, which on adding potash is dissolved with an intensely red colour.

ROCOU.—See *Annotto*.

ROMAN ALUM.—See *Alum*.

ROMAN VITRIOL.—See *Sulphate of Copper*.

ROSIN.

COLOPHONIUM.

1. Common rosin is the residuum left in the still after the distillation of the different species of turpentine. If the

distillation is carried to dryness, the rosin is called common brown rosin, or colophonium ; in the contrary case it is yellow. The latter, or yellow rosin is more soft or ductile, owing possibly to a small quantity of oil (rosin-oil) which it retains ; it is generally preferred and fetches a somewhat higher price, but it is seldom genuine, that is, frequently it is only the common brown rosin which has been rendered yellow by an admixture of *water*. In effect it is sufficient to boil the brown rosin in water for some time, to convert it into yellow rosin. Brown rosin may thus imbibe a good deal of water in a few minutes. This adulteration is detected by exposing the yellow rosin to a dry steam-heat for four or five hours, the genuine yellow rosin remains unaltered, whilst that which has been mixed with water, by losing it returns to the state of brown rosin.

ROUGE VEGETAL.—See *Safflower*.

RUM.—See *Brandy*.

SAFFLOWER.

BASTARD SAFFRON. SAFFRANON. CARTHAMUS.

1. Safflower is in flat cakes, and has the same appearance as saffron, (from which, however, it is readily distinguished by simple inspection,) but it has neither the taste nor odour of saffron.
2. Safflower contains two colouring matters, the one, which is yellow, is soluble in water ; the other is red, and is extracted by carbonate of alkali and citric acid.
3. The best safflower comes from India.
4. Good safflower should yield about five per cent. of red colouring matter, that which is met with in commerce in the

liquid state, under the name of *extract of safflower*, or of *rouge végétal*, is generally mixed with finely pulverized talc. The red colour is extracted by first treating the safflower with cold water for a long time, in order to remove the yellow colour ; the washing must be continued until the water passes colourless through a filter, and by treating it afterwards with alcohol, the red colour is taken up, and may be isolated by evaporating the alcohol.

5. Or after having removed the yellow colouring matter, as just said, the red colour may be extracted by macerating the safflower for an hour or two in its own weight of water, containing one-tenth of its weight of carbonate of soda. The liquor, which should have a very brown colour, should be separated by squeezing the macerated safflower. Skeins of cotton should then be immersed in the liquor, and either lemon juice, or a solution of citric acid, or of tartaric acid, being added in sufficient quantity to saturate the alkali, the liquor becomes red, and the red matter (carthamic acid) becomes soon fixed on the cotton mixed with a little yellow colouring matter, which is subsequently removed by washing with water. The cotton thus treated should now be plunged into a bath, consisting of 20 parts of water and two parts of carbonate of soda ; the cotton becomes immediately decolourized, and after having withdrawn and squeezed it, the red colour is precipitated by pouring lemon juice into the said bath.

6. According to Dumas, the best method of testing safflower consists in taking a weighed sample of the safflower, washing it, and treating it with carbonate of soda, as above said, precipitating the red colouring matter upon a known weight of skeins of cotton, and comparing the depth or intensity of the colour thus obtained with other portions of skeins of cotton of a same weight, dyed with a same weight of safflower of a known quality, or with various samples of safflower, by which their comparative value may be ascertained.

SAFFRANON.—See *Safflower*.

S A F F R O N .

CROCUS.

1. Saffron is met with in commerce usually in round flat cakes (Persian saffron is in cakes of from nine to twelve inches in diameter, and from one half to three quarters of an inch in thickness,) which are formed of the stigmata and styles of the *crocus sativus*, and contain a yellow colouring matter of great intensity, soluble in water. Saffron was originally imported from Persia, but it is now imported also from the continent, and it is prepared besides to a certain extent in England (Cambridgeshire). English saffron fetches a higher price. The filamentous petals of Persian saffron are much larger than those of European saffron, and they are at the same time darker and less imbued with flavour and colouring matter.

2. Good saffron is in long, flexible filaments of a red colour, it has a peculiar aromatic, agreeable, pungent odour, and a warm, somewhat bitter, taste. The cakes should feel a little moist, of a close texture, and stain the fingers. That which contains but few *stamina*, which are easily recognized by their *anthera* and fine yellow colour, is the best. If the cakes have a brown or a pale yellow colour, feel unctuous or clammy, it is a sign that they are too old, or of bad quality, and should be rejected.

3. The price of saffron being always high, it is often adulterated to a great extent by an admixture of other plants, such as the petals of safflower, and other substances. This adulteration is detected by boiling a portion of the sample in water, and comparing the fibres with those of a portion of genuine saffron treated in the same manner.

4. The relative colouring power of the article may serve also as a criterion of its goodness ; the experiment is performed with the colorimeter, exactly as described in the articles on madder and indigo.

5. Sometimes saffron which has been partially deprived of its colouring matter by infusion, is dried and again offered for sale. Such saffron is recognizable by its dull red colour, which is uniform all through, and by its odour, which is much fainter. It scarcely imparts a yellow colour to water or saliva.

SAFFRON (BASTARD).—See *Safflower*.

SAL AMMONIAC.

MURIATE OF AMMONIA. HYDROCHLORATE OF AMMONIA. CHLORIDE OF AMMONIUM.

1. Sal ammoniac is met with in commerce in the shape of colourless, translucent cakes, concave on one side, and convex on the other; or in conical, crystalline, and white masses, hard and somewhat elastic, and, consequently, difficult to pulverize; this salt is inodorous, but has a bitter, acrid, and fresh taste. When pure it crystallizes from its solution in octahedral, cubic, and plumose crystals. Its specific gravity is 1.45. It is inalterable, or very slightly deliquescent in the air; soluble in three parts of cold, and in about its own weight of boiling water; it is completely soluble in alcohol. In dissolving in water it produces cold; it is fused and volatilized without decomposition by heat.

2. Sal ammoniac generally contains but few impurities, which consist principally of a little *sulphate of ammonia*, *chloride of sodium* (common salt), *sulphate of soda*, and *sulphate of magnesia*. Sometimes, also, it contains some *iron* or *lead*; the first substance is derived from the volatilization of a little chloride of iron, with which it combines to form

a double chloride of iron and of ammonia. The second substance (the lead) comes from the contact of the cake of sal ammoniac with the lead dome or cover, against the sides of which it gradually condenses.

3. *Sulphate of ammonia* is detected by dissolving a portion of the sal ammoniac in pure water, and testing the solution with one of chloride of barium, which, if sulphate of ammonia, or any other soluble sulphate be present, will produce a white precipitate of sulphate of baryta.

4. The other impurities are easily detected, because they are fixed, and therefore by heating a portion of the sal ammoniac to redness in a platinum crucible, the impurities will be left behind.

5. If it were desired to identify the presence of iron and of lead, it may be done by dissolving a portion of the sal ammoniac in water, and dividing it into two portions, to one of which a little nitric acid is first added; and if by pouring a drop or two of ferrocyanide of potassium, a blue precipitate is produced, it indicates the presence of iron. The presence of lead is detected by passing a current of sulphuretted hydrogen through the second portion, which produces a black precipitate of sulphuret of lead.

6. The aqueous solution of pure sal ammoniac should have no action whatever upon test-papers; it should not be precipitated or discoloured by either sulphuretted hydrogen or hydrosulphuret of ammonia, nor by a solution of phosphate of soda and ammonia. It should completely volatilize by ignition, and if before the complete volatilization of the salt an abundant residuum of charcoal be observed, it is a proof of the presence of organic matter.

SAL DE DUOBUS.—See *Sulphate of Potash*.

SAL PRUNELLA.—See *Nitre*.

SALTPETRE.—See *Nitrate of Potash*.

SALT (COMMON).—See *Chloride of Sodium*.

SALT OF SATURN.—See *Acetate of Lead*.

SALT OF SORREL.—See *Binoxalate of Potash*.

SEDLITZ SALTS.—See *Sulphate of Magnesia*.

SEED LAC.—See *Shellac*.

S H E L L A C.

GUMLAC.

1. Lac, stick-lac, seed-lac, and shellac, are the names of a substance obtained from incrustations made by an insect (*coccus lacca*), similar to the cochineal on the branches and twigs of several trees in India. The lac is formed by the insect into cells, somewhat similar to a honeycomb, but differently arranged, and in which the insect itself is generally found entire, and owing to whose presence stick-lac may be made to yield by proper treatment a red dye, nearly, if not quite as bright as that obtained from cochineal, and more permanent.

2. Lac in the natural state is found, as we said, on the branches and twigs of certain trees; not superposed, but encircling the branch, at various distances, in the form of a rugged tube, of which the branch is the core, about half an inch, or one inch in diameter. The branches on which the lac is deposited are plucked from the tree, subsequently broken in smaller pieces, and then sent to the bazar. Such lac, containing fragments of branches and other detritus, is

called stick-lac. The best stick-lac, when held against the light, is semi-transparent.

3. The colouring matter is extracted from stick-lac by grinding or pounding it into coarse powder, which after treatment with water, constitutes the *seed lac* of commerce.

4. Shellac is made from either stick-lac or shellac, in the following manner:—The seed-lac, or stick-lac, previously reduced into coarse powder, is mixed with about 15 per cent. of an Indian resin called dammar, but more frequently, and we might say almost generally, with common yellow rosin, exported from England to India, and the mixture is then put into a small calico bag, about 2 inches in diameter, and about 2 feet or $2\frac{1}{2}$ feet in length. The bag is held over a charcoal fire, and as soon as the contents have sufficiently softened, the bag is twisted, and the lac, oozing through the meshes of the calico, is scraped off with the blade of a long knife, and whilst yet hot and soft, it is scraped from the knife against the stem of a plantain tree, and flattened thereon with the stalk of a leaf of the same tree; when cold, the shell or plate of lac is easily detached from the stem of the tree, and this constitutes shellac. The thinness of shellac depends on the degree of pressure and of fluidity of the lac, and the shellac exhibits generally on one side the marks of the stem of the tree on which it has been flattened.

5. Shellac is packed in India in strong wooden chests, but during the journey to England the temperature in the hold of the ship is often sufficient to soften the pieces of shellac, which then adhere together, so as to convert the contents of a chest into one solid lump of lac. Shellac which has thus agglomerated is known under the name of *lump lac*. The quality and usefulness of the lac is not thereby deteriorated or diminished in the slightest degree, though the commercial value of such lac is singularly depreciated, sometimes to a considerable extent. A few years ago I was consulted in reference to shellac, which, with a view to economise freight, had been sent over to this country in sticks or rolls, instead

of in shells or plates. These sticks or rolls were about one inch in diameter, and about a foot in length, of a good colour; they melted readily at the usual heat, dissolved completely in spirits of wine, in naphtha, in solution of carbonate of soda and of borax; when fused and pressed upon a cold glass-bottle they formed a shell in every respect similar in appearance, quality, and usefulness, to the best liver shellac, and yet of the 1,500 chests, or thereabouts, which had been sent over to this country, each weighing about 2 cwt., not one could be sold, and the whole had, in consequence, been left in the warehouses of the East India docks for seven years when my attention was called to the subject. To become marketable, it was necessary to reduce these sticks or rolls of lac into flakes or shellac, and this was a great difficulty, for although lac can with impunity be exposed almost to a red heat, provided it be applied only for a moment, a temperature of 300° Fahr., a degree of heat at which lac becomes just sufficiently fluid to be moulded, or pressed into flakes, if continued for even a short time, five or six minutes for example, is sufficient to alter its properties; it becomes first thickish, then leathery, in which state it will burn, but will not run or flow; it has become insoluble in all menstrua, and is then altogether spoilt. I succeeded, however, in effecting the object in view, by means of an apparatus consisting of an iron pipe coiled in the shape of a funnel, through which water was made to circulate at a temperature of 300° Fahr., by means of a Perkin's stove. The sticks or rolls of lac were then put into the coil, and as they gradually came in contact with the heated pipe, they melted, and immediately oozed out between each coil, and thence fell between a pair of cast iron rollers, turned smooth, by which the melted lac was laminated into a thin uninterrupted stream, or band, which was carried into a large box or bin, from which it was packed in boxes in the usual way, as occasion required. The first chests which were thus offered for sale, however, could find no purchaser, not because the shellac was not good, but,

indeed, because it had not on *one* side the marks of the plantain tree which have been already alluded to at the beginning of this article ; neither could the consumers be persuaded to try it, until after the imprint in question had been actually imitated by circularly filing one of the iron rollers which transferred to the lac, as it passed through, the appearance of the longitudinal fibres of the tree. It was further necessary so to increase and yet regulate the heat, that after passing through the rollers, the shellac could still retain sufficient fluidity to become glossy. With these additional precautions the shellac could not be distinguished in either look or properties from the ordinary shellac, and it then found a ready market.

6. Thin, transparent, and *orange-coloured* shellac is the best ; the next quality, which is almost as highly prized, is *ruby shellac* ; then comes the *liver shellac*, so called from its brownish colour. Ruby shellac is much harder than either orange or liver shellac, and contains much less dammar or rosin ; it makes accordingly a harder varnish, of a bright mahogany colour. Orange shellac contains a large portion of dammar, and fuses almost like wax.

7. When shellac breaks with a dull fracture and with ragged edges, it has been overdosed with rosin. Good shellac, on breaking, should snap with a clear sound, and the edges should have a smooth, horny appearance, like strong glue. When a handful of shellac is poured from one hand to the other, or back again into the chest, the noise produced should be clear and sharp. The thickness or thinness of shellac is no criterion, either of good or of bad quality ; yet orange shellac, from its greater fusibility, is generally in exceedingly thin flakes, and the best *ruby shellac* is in roundish pieces about $2\frac{1}{2}$ inches in diameter, and is then known under the name of *button shellac* ; it exhibits also the marks of the plantain tree on one side, which orange shellac seldom does. *Liver shellac* is in thicker flakes than orange shellac, but is thinner than *button shellac*.

8. *Stick-lac*, *seed-lac* (except the impurities, such as fragments of branches, and of insects), *lump*, and *shellac*, should completely dissolve in alcohol, naphtha, and in alkaline water. These criteria are of great importance, for stick-lac, and more especially seed-lac, are often adulterated to an incredible extent. I examined once a large number of samples of seed lac for a London merchant, and I found them mixed with from 56 to 95 per cent. of insoluble gum ! The fraud had been practised by the natives in India, and the importer accordingly suffered a most serious loss.

SILK.—See *Cotton*.

S I L V E R.

1. Silver is the whitest of all metals ; when it has been precipitated from a solution by a metallic bar, one of copper, for example, it is in the state of a spongy mass, consisting of crystalline grains, which may be rendered very cohesive by pressure, or hammering. When melted and cooled slowly, it crystallizes in voluminous octahedrons, or in cubes. Silver is odourless and tasteless, a little harder than gold, but less so than copper ; next to gold it is the most ductile and the most malleable of metals. Silver melts at about 1873° Fahr. When fused in close vessels it does not volatilize, but when exposed to a current of air or of gas it does rapidly. Pure silver when in a state of fusion may absorb twenty-two times its weight of oxygen, but a small proportion of copper is sufficient to prevent this absorption. The silver, on cooling, abandons the oxygen, and in so doing shoots up and spurts, producing a rough surface, or a sort of metallic vegetation. The analysis of the alloys of silver is made either by cupellation, or in the humid way.

ASSAY OF SILVER BY CUPELLATION.

1. This method is more generally employed, silver being a metal which is not oxydized by the air, and which is not sensibly volatile at a high temperature; it may be separated, by cupelling, from the other oxydizable metals with which it may be alloyed, and which, being fused, are absorbed by the cupel, on which the silver is retained as upon a filter.

2. Cupels are made of finely pulverized bone-ashes. The powder is tempered with water into a somewhat moist paste, which is then compressed into a mould by means of a mandril and hammer. The cupels being removed from the mould, are dried, and they generally are of such thickness as to be able to absorb their own weight of fused litharge.

3. In order to promote the oxydization of the base metals alloyed with the silver, and which generally consist of copper, it is necessary to add lead, the quantity of which must be increased according to the proportion of the copper existing in the alloy. This proportion of copper should therefore be approximatively determined, before proceeding to the actual analysis or assay of the alloy. This may be done by cupelling, at once, one grain of the alloy with 20 grains of lead; the button of silver left upon the cupel represents the real quantity of silver within 2 per cent. From this preliminary assay the operator learns what quantity of lead he should add.

4. 20 grains of alloy is generally the quantity taken for the assay; they should be very accurately weighed in a very delicate balance, and the weight of the button obtained after cupelling, multiplied by five, will therefore give the percentage of silver contained in the alloy. If, for example, the button of silver left on the cupel weighs 18 grains, the alloy contained, therefore, $\frac{18}{20}$ of silver, or 90 per cent. of silver ($18 \times 5 = 90$).

5. The portion of the sample of silver to be assayed

x 5

should be first flattened, by hammering it upon a small, clean, steel-anvil; and if the surface of the silver be soiled, it should be scraped clean.

6. 20 grains of alloy are generally operated upon, as we said, yet it is not advisable to operate upon so much when the alloy contains less than 80 per cent. of silver. When the alloy to be examined is under 80 per cent., it is better to take only 10 grains, in order to reduce the necessity of cupelling so much lead. In that case, the result of the weight of the button after cupellation, multiplied by five, as above said, should of course be doubled, in order to obtain the per centage of the silver contained in the alloy.

7. The quantities of lead which are necessary for the cupellation of various alloys of silver and of copper, are as follows :—

Silver per cent.		Silver, In 20 grains.		Lead necessary for cupelling 20 gr. of Silver Alloy.
Silver. 100 gr. in	Alloy. 100 gr.	Silver. 20 gr. in	Alloy. 20 gr.	
95	— 100 "	19	— 20 "	— 6 grains
90	— 100 "	18	— 20 "	— 60 "
80	— 100 "	16	— 20 "	— 140 "
70	— 100 "	14	— 20 "	— 200 "
60	— 100 "	12	— 20 "	— 240 "
50	— 100 "	10	— 20 "	280 "
40	— 100 "	8	— 20 "	320 to 340
30	— 100 "	6	— 20 "	
20	— 100 "	4	— 20 "	
10	— 100 "	2	— 20 "	
Pure copper.		Pure copper.		

8. Let us suppose, for example, that the preliminary assay has indicated $\frac{16}{20}$, or 80 per cent. of silver; that is to say, suppose that the 20 grains of alloy have yielded 16 grs. of silver ($16 \times 5 = 80$). The operator takes then the quantity of lead marked in the table as corresponding to that per centage, namely, 200 grains, and he puts it into the cupel, previously heated to a bright red in the muffle. The cupel should be placed near the middle of the muffle, or rather, a

little more towards the mouth of the muffle than quite in the middle. The cupel, before using it, should have been held for some time at the mouth of the muffle, in order to dry it thoroughly, and it must have been gradually brought to the proper heat before placing the lead in it, for without this precaution the slightest pressure of the cupel-tongs are often sufficient to break it. A cupel, after having been once brought to a red heat and cooled, is unfit for use, because on re-heating, it becomes full of small cracks. These precautions being borne in mind, as soon as the lead has melted and has become bright, the operator must add 20 grains of the alloy, carefully weighed, as before said, and wrapped up in a piece of paper, or of lead-foil (the lead must be pure and obtained by reducing litharge); or else the 20 grains of alloy may at once be wrapped in the appropriate quantity of lead-foil, and put into the red-hot cupel within the muffle.

9. It is best, however, to fuse the lead first, and to wait until it *has become bright* before adding the silver wrapped up in paper, because otherwise a portion of the oxyde of lead which is formed when the lead begins to fuse, would be reduced by the charcoal of the paper containing the silver, and the carbonic acid thus produced and disengaged, might cause a projection of a little silver, and vitiate the experiment.

10. The silver-alloy thus introduced into the cupel soon fuses, and the air, playing on the surface of the molten mass, soon oxydizes the copper and the lead, the surface of the fused mass gradually assuming a convex shape, whilst drops of an oily appearance, which are produced by the fused oxydes, are observed, and are rapidly absorbed by the cupel. A portion of the lead evaporates in the shape of fumes, which fill up the muffle, and escape in the chimney through the openings in the sides. As the mass in the cupel gradually assumes a convex shape, bright sparks are observed moving rapidly, and when the mass is seen to be reduced to about two-thirds of its original bulk, the cupel is drawn forward,

more towards the edge or mouth of the muffle; the bright sparks above alluded to immediately disappear, and are replaced by iridescent bands, produced by excessively thin films of oxyde of lead; at last the button of silver becomes fixed, then dull, and at last very bright; this indicates that the experiment is at an end. The cupel must now be gradually drawn nearer the edge or mouth of the muffle; this must not be done too suddenly, for the deoxydized button, if cooled too rapidly, will spurt, and perhaps project a small portion of silver out of the cupel. If the heat has been carefully managed, and the proper precautions just mentioned attended to, the button of pure silver, on being removed from the cupel by a small pair of forceps, will be found scarcely to adhere; and after brushing, washing, and cleaning it, its surface should be convex, perfectly even, without vegetation or depression, and perfectly bright; its base, that is, that portion which was in contact with the cupel, should be clean and dead white, like frosted silver. If the button strongly adheres to the cupel, if its surface be dull, and its edges sharp, instead of rounded, it is a proof that the heat has not been sufficient, or that too little lead has been added. If, on the contrary, a depression or a vegetation is observed on the surface of the button, it is a proof that the heat was too strong, or that it was cooled too suddenly.

11. In order to carry the operation to a successful issue, it is necessary that the cupel should be perfectly smooth, without cracks, and not too dense, in order that the whole of the litharge may be absorbed. The bone ashes employed to make cupels should be sifted through a horse-hair sieve, and washed on a filter with boiling water, in order to remove the soluble salts which it might contain. The cupels, after being made, should be dried and then put aside.

12. The cupels used for alloys which are very poor in silver, and which would consequently yield a very small button, should be made of levigated bone ash.

13. The determination of the proportion of silver by

cupellation requires a good deal of practice, the accuracy of the assay depends upon the management of the proper degree of heat of the cupelling furnace. If the temperature be too high, some silver will be lost by volatilization and imbibition in the cupel ; if too low, the silver button retains some lead mixed with the silver. The knowledge of the proper management of the heat of the cupelling furnace, so essential to the accuracy of the analysis, can be acquired only by experience. We will add, that it is absolutely requisite not only to bring the furnace to the requisite temperature, but it must be maintained at that temperature by keeping it full of red hot coke. At the beginning of the assay, white fumes may be observed, which are due to the volatilization of a portion of the lead ; the appearance of these fumes may serve as a guide in the management of the heat. For example, if these fumes of oxyde of lead rise up quickly and vertically in the muffle, it is a proof that the temperature is too high ; the cupel should therefore be drawn towards the mouth of the muffle, in order to cool it a little. If, on the contrary, the fumes do not rise up, but move about on the floor of the muffle, then it is a sign that the temperature is not high enough ; the cupel should therefore be pushed farther into the muffle. The temperature is right when the fumes rise up in wreaths, and the portion of the cupel which is bathed by the fused mass, should, as the melted mass diminishes, appear of a reddish brown colour. If it be white, the temperature is too high ; if it be almost black, the temperature is too low. Even when all these precautions have been attended to, the experiments of Tillot and D'Arcet have proved—

14. 1st. That the per centage of silver indicated by the assay is always a trifle below the real per centage, which is due to a partial volatilization and imbibition of the silver.

15. 2nd. That the button does not rigorously consist of pure silver, but that it retains always a trace of lead and of copper ; for when analysed in the humid way, the button is found to contain between $\frac{992}{1000}$ and $\frac{998}{1000}$, the mean being $\frac{996}{1000}$ of silver.

That is to say, the buttons obtained by cupellation, contain generally about 0.004 of foreign metals. This, however, for technical or commercial purposes is a very trifling error, yet, considering that the loss of silver sustained by cupelling is always more considerable than the weight of the impurities, we join here a compensation table, which approximatively indicates that loss :—

COMPENSATION TABLE FOR THE ASSAY OF SILVER
BY CUPELLATION.

Weight obtained after cupelling 20 grains.	Compensating quantity of pure silver to be added to the weight obtained.	Real quantity of silver contained in 20 grains of assay.	Real per centage of silver in the assay.
19.979	0.02	20	100
18.95	0.05	19	95
17.92	0.08	18	90
16.917	0.083	17	85
15.914	0.086	16	80
14.91	0.09	15	75
13.905	0.095	14	70
12.905	0.095	13	65
11.906	0.094	12	60
10.906	0.094	11	55
9.906	0.094	10	50
7.921	0.079	8	40
5.948	0.052	6	30
3.949	0.051	4	20
1.982	0.018	2	10

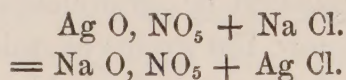
16. When the quantity of silver is very small, as, for example, in the lead of commerce, which sometimes contains only three ounces to the ton, or even less, cupellation must always be resorted to, as the results obtained by the humid way in such cases are quite erroneous. The quantity which, I think, answers best for cupelling such alloys is 500 grains, and from that quantity 0.0148 of silver, including compensation for loss, represents one ounce of silver to the ton. A

cupel may absorb its own weight of lead ; if the quantity of lead to be absorbed is more considerable, another cupel may be turned topsy-turvy, and the cupel in which the assay is to be made may be placed upon it.

ASSAY OF SILVER IN THE HUMID WAY.

17. When soluble chlorides are added to a solution of silver, a precipitate which is completely insoluble in water and in acids is formed, which settles rapidly, and the solution of silver operated upon is left in a perfectly clear and limpid state. It is then easy to ascertain whether the chloride employed is in excess, for in that case, an addition of nitrate of silver will produce a precipitate ; or if the chloride was not used in sufficient quantity, a drop of its solution will render the silver-liquor turbid.

18. The test-liquors employed in this mode of analysis are :—1st., a test-liquor of nitrate of silver ; 2ndly., a test-liquor of chloride of sodium, both of which are so prepared, that when mixed together in equal volumes, the whole of the silver is precipitated as chloride of silver, and only nitrate of soda remains in solution, as shown by the following equation.—



19. The test liquors are prepared in the following manner :—

Test-liquor of nitrate of silver.

20. Taking the equivalent of nitrate of silver as 170. Dissolve 170 grains of pure nitrate of silver into 10,000 grains-measure, (1000 alkalimetric divisions) of pure water. Each division of ten grains-measure will therefore contain 0.108 grain of pure silver, which represents 0.036 of chlorine, and, consequently, 0.144 grain of chloride of silver. Or, in

other words, the 10,000 grains-measure containing one equivalent of nitrate of silver, represent, of course, or will be entirely precipitated, by one equivalent of chloride of sodium, and will produce accordingly one equivalent of chloride of silver.

21. The nitrate of silver used for the preparation of the test-liquor should, of course, be pure, that sold for photographic purposes is generally good; when this cannot be obtained, the operator may operate with pure silver, which can be obtained by dissolving ordinary silver coins in commercial nitric acid, and decanting the clear solution from any residuum which may be left. The clear decanted liquor should then be precipitated by an excess of solution of common salt in the state of chloride of silver, which is collected on a filter, thoroughly washed, dried, and reduced in a hessian crucible exposed to a bright red heat, by mixing it therein with chalk and charcoal, in the proportions of 70.4 parts of chalk, and 4.2 parts of charcoal, for 100 of the dry chloride of silver produced, which yields a button of silver; it should be washed and redissolved in nitric acid, again precipitated by solution of common salt, and reduced a second time by chalk and charcoal, as above said. The button found at the bottom of the crucible is then perfectly pure, and it may be laminated or granulated for greater convenience. Taking now 108 grains of this pure silver, and dissolving them in about one and a half ounce of *pure* nitric acid, and diluting the solution with water, so as to produce 10,000 grains-measure, the operator will have a pure test-liquor.

Test-liquor of chloride of sodium.

22. Taking the equivalent of chloride of sodium = 60. Dissolve 60 grains of pure chloride of sodium into 10,000 grains-measure (1000 alkalimetical divisions) of pure distilled water. Each division of 10 grains-measure will there-

fore contain 0.060 of chloride of sodium, and, consequently, 0.036 of chlorine, which represents, therefore, 0.108 of pure silver. Or, in other words, since the 10,000 grains-measure contain one equivalent = 60 of chloride of sodium, by mixing them with the 10,000 grains-measure of the test-liquor of nitrate of silver, we should obtain exactly one equivalent, = 144 of chloride of silver, in the shape of a white precipitate, and the supernatant liquor should not retain a trace either of nitrate of silver, or of chloride of sodium. That is to say :— if the test-liquors are right, any given and equal number of divisions of each being poured from the alkalimeter into each other, should precipitate all the silver, and the supernatant liquor should not be rendered turbid, when tested in two separate portions by solution of nitrate of silver, or of chloride of sodium.

23. The common salt of commerce may be used for the preparation of the test-liquor, but as it is not perfectly pure, it will, of course, be necessary to test it with care, with the nitrate of silver test-liquor, as above directed, and to adjust it to the proper strength, which is done exactly as described in alkalimetry. Let us suppose, in effect, that after having measured out 1000 grains-measure of the nitrate of silver test-liquor in a glass-beaker, and filled the alkalimeter up to 0° with the test-liquor of chloride of sodium (common salt), it is found that 90 divisions (900 grains-measures) of the solution of chloride of sodium have been sufficient to precipitate the whole of the silver contained in the 1000 grain-measures of nitrate of silver in the glass-beaker, it is clear, in that case, that the common salt test-liquor is too strong, and therefore, it should be diluted with 10 divisions (100 grains-measures) of water to bring it to the proper strength. This is best accomplished by pouring the whole of the chloride of sodium test-liquor into a large glass-cylinder, accurately divided into 100 parts, until it reaches the mark indicating 90, and the rest of the glass is then filled with water, up

to 100, so that the same quantity of chloride of sodium will now be contained in 100 divisions, as was contained before in 80.

Actual assay of the alloy in the humid way.

24. The test-liquor of chloride of sodium having been adjusted to the proper strength, as above described, take 10 grains of the alloy under examination, accurately weighed, and dissolve them at a steam heat, in a flask, with five or six times their weight of pure nitric acid, specific gravity 1.283. When dissolved, the vapours of nitrous acid which fill the flask should be expelled, either by means of a pair of bellows with a glass-nozzle, or simply by introducing a glass-tube into the flask, near the surface of the liquid, and blowing through the tube. This being done, fill the alkalimeter (see the article on *Alkalimetry*) up to 0° with the test-solution of chloride of sodium, and pour gradually and carefully therefrom, into the flask containing the solution of silver, a certain number of divisions; the silver solution is then briskly agitated, or shaken, in order to promote the rapid settling of the chloride of silver produced, and when the supernatant liquor has become quite clear, a fresh portion of the chloride of sodium is added, if necessary, that is, until it nearly ceases to produce a precipitate. The operator now takes a pipette, graduated into grains, and he fills it with the same chloride of sodium test-liquor up to a certain number of divisions, 10 of which represent 1 of the alkalimeter. When the liquor in the flask has become again quite clear, the operator drops 1 grain-measure from the dropping-tube, as long as it continues to produce a cloud; when it no longer does so, it is a sign that all the silver is precipitated. Supposing, for example, that 12 such grains-measure having been dropped from pipette, and having produced a cloudiness at each grain so added, the thirteenth

addition produces nothing, it is evident that this thirteenth grain-measure from the pipette must not be counted. The operator then reckons the whole number of divisions which have been used, both from the alkalimeter and from the pipette, and calculates therefrom the quantity of silver contained in the alloy.

25. Let us suppose for example, that 66 division-measures of the test-liquor of chloride of sodium have been employed from the alkalimeter, and 12 divisions (13 divisions — 1 in excess = 12) from the pipette; since 10 divisions of the pipette are equivalent to 1 of the alkalimeter, it is as if 67.2 divisions of the alkalimeter had been employed; and as 100 divisions of the alkalimeter (1000 grains-measure) represent exactly 10.8 grains of silver, 67.2 divisions of the alkalimeter represent, therefore, 7.2576.

$$100 : 10.8 :: 67.2 : x = 7.2576.$$

The number thus found, multiplied by 10, gives the per centage of the alloy. The 10 grains operated upon, contained, therefore, 7.2576 of silver, or 72.576 per cent.

26. It is seldom, however, that the exact saturating point can be accurately hit by a first trial, and in order to rectify the excess of chloride of sodium employed, the operator may ascertain that quantity by assaying it with the test-solution of nitrate of silver, above mentioned, and which he may pour from a pipette into the clear supernatant liquor of the precipitated chloride of silver. If on adding a drop of the test-solution of nitrate of silver a cloudiness is produced, it is evident that an excess of chloride of sodium has been employed, the amount of which may thus be readily ascertained, and deducted from the result first noted. Suppose, for example, that it be found that 5 divisions of the test-liquor of nitrate of silver in the pipette are requisite to neutralize the excess of chloride of sodium, then the total and net number of divisions employed would be thus—

From the alkalimeter	.	.	.	66.0 Divisions.
From the pipette	13 grain-divisions.			
Less by rectification	5	ditto.		
		8	=	0.8 ditto.
		Net number		66.8 ditto.

And the result is 72.144 per cent. of silver—

$$100 : 10.8 :: 66.8 : x = 7.2144 \times 10 = 72.144.$$

27. It is better, however, to endeavour to hit the exact point as near as possible by a first experiment, and to repeat it a second time with caution, as the approximative point determined by the first experiment is approached, than to try to correct the error, as just said, because it is difficult in that way to obtain a clear liquor, which is of absolute importance to the success of the experiment.

28. In order to guard against variations in the degree of concentration, or of dilution of the test-liquors employed, by evaporation or change of temperature, they should always be carefully examined before using them ; this is very easily and rapidly done, by ascertaining whether any given number of measures of the chloride of sodium test-liquor will exactly precipitate all the silver contained in a corresponding number of the test-liquor of nitrate of silver.

29. We should remark also, that when the alloy under examination contains mercury or sulphuret of silver, the estimation of the silver in the humid way is rendered incorrect, because, in that case, the mercury is precipitated along with the silver, and the proportion of the latter metal appears then larger than it really is ; on the other hand, if sulphuret of silver be present, the assay indicates less silver than is really contained in the sample, because sulphuret of silver, resisting the action of the nitric acid, cannot, of course, be subsequently precipitated by the chloride of sodium test-liquor.

30. The presence of mercury is detected in the alloy, because, in that case, the chloride of silver precipitated is not blackened by the influence of solar light. The mercury falls down in the state of chloride, with the first portions of silver which are precipitated by the solution of chloride of sodium.

31. According to M. Levöl, the analysis of silver in the humid way may be correctly performed, notwithstanding the presence of mercury, in the following manner :—The silver should be approximatively precipitated from the nitric acid solution, as above described, by means of the chloride of sodium test-liquor, and the precipitated chloride of silver being redissolved by ammonia, is reprecipitated by saturating the ammoniacal liquor with acetic acid. The analysis proceeds then in the usual way. This modification, according to Gay Lussac, may be simplified, by adding at once to the nitric acid-solution of the silver a mixture of acetic acid and of ammonia, in sufficient quantity to saturate all the nitric acid existing in the liquor, either in the free state, or combined with the silver. Crystallized acetate of soda may also be employed instead of acetate of ammonia, but the whole of the mineral acid must be entirely saturated by the acetate of soda.

32. The presence of sulphuret of silver is detected whilst dissolving the 10 grains of the sample in nitric acid, because black flakes are observed floating about in the liquor in an insoluble state. These flakes, however, may be dissolved by fuming nitric acid, or by adding pure concentrated sulphuric acid to the solution, which should be then kept for about a quarter of an hour in a steam-bath. When thus treated, the precipitate produced by the test-liquor of chloride of sodium represents the whole of the silver contained in the alloy.

33. When the alloy contains *lead*, the test-liquor of chloride of sodium, which would produce a precipitate of chloride of lead, should be replaced by one of chloride of lead, in which case 140 grains of chloride of lead (1 equivalent)

should be dissolved into 10,000 grains-measure of water, and the analysis proceeds as with that of chloride of sodium. When, however, the quantity of silver is very small, as in the lead of commerce, the analysis should always be performed by cupellation, for the humid way does not yield results entitled to any confidence.

34. Silver, according to M. Levol, may be speedily and gradually reduced from chloride of silver, by boiling the latter with a solution of potash containing a little sugar ; carbonic acid is disengaged pending the reduction.

SILVER (AMALGAMATED).—See *German Silver*.

SIMILOR.—See *Brass*.

SIZE.—See *Glue*.

S M A L T.

A Z U R E B L U E.

1. Smalt is a blue glass, which is prepared by fusing zaffre with colourless glass, or by calcining a mixture of equal parts of roasted cobalt-ore, pearlash, and ground flints ; the result is a blue glass, which, whilst red-hot, is thrown into cold water, and afterwards reduced into impalpable powder. Smalt is much employed in the potteries, in the manufacture of paper, and for other purposes.

2. The composition of smalt, of the best quality, is as follows :—

Protoxyde of cobalt . . .	14.7
Oxyde of iron . . .	4.2
Oxyde of lead . . .	4.7
Alumina . . .	5.0
Potash . . .	14.1
Silica . . .	54.8

3. Smalt is sometimes adulterated with chalk ; this fraud, however, may be immediately detected by pouring a little hydrochloric acid upon it, which, in that case, will produce an effervescence.

4. The analysis of smalt is performed exactly like that of glass. (See the article on *Glass*.)

SMELLING SALTS.—See *Carbonate of Ammonia*.

S O A P.

1. Soap is a most important article of manufacture and of commerce ; it is a compound resulting from the combination of certain constituents, derived from fats, oils, grease, and rosin, with certain salifiable bases, which in detergent soaps are potash or soda.

2. Oils and fats consist chiefly of three principles, of different consistency, the one more fluid than the two others. The first is called oleine, and is always liquid at the ordinary temperature ; the two others are called stearine and margarine. These substances, chemically considered, are really salts, or combinations of an oxyde with an acid, that is to say, are the result of the combination of stearic, margaric, oleic acid, &c., with the oxyde of a compound radical, called *glyceryle* (sweet principle of oils). Stearine being therefore

a combination of stearic acid with oxyde of glyceryle, is a stearate of oxyde of glyceryle ; oleine is oleic acid + oxyde of glyceryle, or oleate of oxyde of glyceryle ; margarine is margaric acid + oxyde of glyceryle, or margarate of oxyde of glyceryle, &c. Glycerine is a combination of oxyde of glyceryle with water, or hydrate of oxyde of glyceryle. Now, when these substances (namely, oleine, stearine, margarine, &c., or the fats or oils which they constitute) are treated by a solution of potash or of soda, their constituents react upon each other, and combine with the potash or soda to form soap. The following diagram exhibits this interesting reaction :—

Substances employed.	Composition.	Products of reaction.
Fats or oils <i>i.e.</i> oleate, stearate, margarate, &c. of oxyde of glyceryle.	Oleic acid Stearic acid Margaric acid, &c... + Oxyde of glyceryle...	Oleate. Stearate. Margarate, &c. of Potash, or of soda, <i>i.e.</i> SOAP.
Potash or Soda.....		
Water.....		Hydrate of oxyde of glyceryle, <i>i.e.</i> gly- cerine.

3. The soap made with soda is hard, that made with potash is soft, and the degree of hardness or of softness depends moreover upon the quantity of stearine and margarine, or of oleine contained in the fat or oil employed. Hence the more oleine a fatty matter contains relatively to the stearine and margarine, the softer the soap made with it will be, and *vice versâ*. The softest soap would, therefore, be that made altogether with oleine (oleic acid), and potash (oleate of potash); the hardest would be that made with

stearine and soda (stearate of soda). Ordinary soaps, however, are mixtures of these fatty acids in variable quantities, according to the species of fat or oil employed. The oils or fatty substances employed for the manufacture of soap are olive-oil, tallow, lard, hempseed-oil, oil of almonds, oil of linseed, horse-oil or fat, rape-oil, poppy-oil, train-oil, cod-oil, and other fish-oils, cocoa nut-oil, palm-oil, kitchen and bone-fat, rosin. This last substance (rosin) always makes, even with soda, a soft, viscid kind of soap, owing to its great affinity for water, so that, even after having been artificially dried, the soap made with it deliquesces by exposure, and returns to the soft state.

4. On the Continent olive-oil, mixed with about one fifth of rape-oil, is principally used for making hard soap. This addition of rape-oil is always resorted to, because olive-oil alone yields a soap so hard and so compact that it dissolves only with difficulty and slowly in water, which is not the case with rape-oil, or other oils of a similar nature, that is, oils which become thick and viscid by exposure, experience having taught that the oils which turn viscid the soonest by exposure, yield with soda a softer soap than that made with oils which, like olive-oil, remain limpid for a long period under the influence of the air. The admixture of rape-oil has therefore the effect of modifying the degree of hardness of the soap. In England tallow is used instead of olive oil, the soap resulting from its treatment with soda is known under the name of *curd soap*.

5. Like pure olive-oil-soap, tallow-curd-soap is very hard, and of exceedingly difficult solution. The small cubic mass of white, waxy, stubborn substance, generally met with on the washing-stand of bedrooms in hotels, and which for an indefinite period passes on from traveller to traveller, each in turn unsuccessfully attempting by various devices and cunning immersions in water to coax it into a lather—is *curd soap*. The admixture of one-fourth or one-fifth of rosin with tallow, in the process of saponification, modifies the

hardness and solubility of curd-soap in a remarkable degree, and this constitutes the best yellow soap.

6. I said that soap was more or less hard in proportion to the quantity of stearine and margarine, &c. contained in the fat or oil, and that certain fatty matters, technically called *weak goods*, such as kitchen-fat, bone-fat, could hardly be used alone, the soap which they yield being too soft, and melting or dissolving away too rapidly in the washing tub. This led me to think, that if a means could be devised of artificially hardening soap, the fats above mentioned, under the name of weak goods and rosin, could then be employed to a much greater extent. In making experiments with this view, I found that the introduction of a small quantity of fused sulphate of soda into the soap answered the purpose admirably, and that the salt in concreting imparted to the soap, which otherwise would have been quite soft, a desirable hardness, and prevented its being wasted in the tub. The use of sulphate of soda acts, therefore, *inversely*, like the addition of rape-oil to olive-oil, or of rosin to tallow in the manufacture of that important article; sulphate of soda has moreover, the property of improving the colour of the soap, and of imparting to the water a peculiar unctuous feeling. The proportion of sulphate of soda should not be more than $\frac{1}{20}$ th of the soap. This process, which I patented, has been to me a source of annoyance and molestation on the part of the Board of Excise, which I think has no parallel, even in the archives of excise practice, and which the fear of obtrusion, in entertaining the reader about my personal affairs, alone prevents me from relating here.

7. There are two kinds of hard soaps, besides curd-soap above alluded to, namely, mottled soap, and yellow *fitted* soap.

8. Mottled soap has a marbled, or streaky appearance; that is to say, veins of a bluish or slate colour pervade its mass, which is white or whitish; the size and number of these veins depend on the more or less rapid cooling of the

soap after it has been *cleansed*, that is, transferred from the copper to the frames. The blue or slate colour of these streaks is chiefly due to the presence of an alumino-ferruginous soap interposed in the mass, and frequently, also, to that of sulphuret of iron, which is produced by the re-action of the alkaline sulphurets contained in the soda-ley upon the iron, derived from the iron, copper, and utensils employed in this manufacture, or, which even is, at times, introduced purposely in the state of solution of protosulphate of iron. The veins gradually disappear, by keeping, from the surface to the centre, by the oxydization of the sulphuret of iron. A well manufactured mottled soap cannot contain more than 33, 34, or at most 36 per cent. of water. It is evident in effect, that the mottling being due to the presence of sulphuret of iron held in the state partly of demi-solution and of suspension, the addition of water would cause the colouring substances to subside, and a white, unicoloured, or *fitted* soap, would be the result. This addition of water, which is technically called *fitting*, is made when the object of the manufacturer is to obtain a unicoloured yellow or white soap. After *fitting*, the soap contains, therefore, an additional quantity of water, which sometimes amounts to 55 per cent., and which is sold at the price of soap. The interest of the consumer is therefore clearly to buy *mottled soap* in preference to yellow or white soap ; the mottling is a sure criterion of genuineness, for the addition of water, or of any other substance, would infallibly destroy the mottling.

9. To yellow or white soap, on the contrary, incredible quantities of water may be added. I have known five pails of water (15 gallons) added to a frame of already fitted soap (10 cwts.), so that the soap after this treatment contained upwards of 60 per cent. of water. Common salt had been previously dissolved in the liquor. The proportion of water in fitted soap has also been in some instances augmented by submitting the bars of soap to the action of high pressure steam in steam-tight chests, or bins. Another way

was by boiling the soap in high pressure coppers before *cleansing*.

10. Cocoa-nut oil soap has the property of absorbing one third more water than the soap made of any other material. A sample of cocoa-nut oil soap from a Liverpool house which I analyzed, contained 79.3 per cent. of water, and 17.2 of cocoa-nut oil, yet it was quite hard, but instantly dissolved into a thin ropy fluid in boiling water.

11. Besides water, soap is often adulterated by gelatine (known as bone-soap), which is made by adding to the soap a solution of disintegrated bones, sinews, skins, hoofs, sprats, or other cheap fish, in strong caustic soda; also by dextrine, potato-starch, pumice-stone, silica, plaster, clay, salt, chalk, carbonate of soda, &c. &c., and by fats of another or inferior kind than those from which they are represented to have been made.

12. The impurities may be detected, and their amount ascertained, in the following manner :—

Estimation of the quantity of water.

13. For the purpose of determining the quantity of water, about 2,000 grains of the soap under examination should be cut into small, thin shavings. These 2,000 grains should not be taken from the outside only, which is always drier, but should be cut off from the whole mass, externally and internally, so that they may represent a fair average. These shavings should be well mixed together, and 100 grains thereof being accurately weighed, should then be placed in an oven, at a temperature not exceeding 212° , until they no longer diminish in weight. The loss indicates the proportion of water; the loss of water in mottled soap should not be more than from 30 to 35 per cent; in white or yellow soap more than 45 to 50 per cent.

14. If the soap contains clay, chalk, silica, dextrine, fecula, pumice-stone, ochre, plaster, salt, gelatine, &c. &c., dissolve

100 grains of the suspected soap in alcohol; with the help of a gentle heat, the alcohol will dissolve the soap, and leave all these impurities in an insoluble state. Good mottled soap should not leave more than 1 per cent. of insoluble matter, and white or yellow soap less still. All soap to which earthy or siliceous matter has been added, is opaque instead of being transparent on the edges, as is the case with all genuine fitted soap. The drier the soap, the more transparent it is.

15. Bone-soap, or glue-soap, is recognized by its dark colour, its want of transparency on the edges, and a disagreeable odour of glue; that made with the fat of the intestines of animals has a disgusting odour of *faeces*.

16. When uncombined silica has been added to soap, its presence may be readily detected by dissolving the suspected soap in alcohol, as we said before, when the silica will be left in an insoluble state; but if the silica is in the state of silicate of soda or of potash, it is necessary to proceed as follows:—a given weight of the suspected soap should be first dissolved in a suitable quantity of boiling water, and decomposed by the gradual addition of moderately dilute hydrochloric acid. The fatty acids which separate being removed, the acid liquor should be evaporated to dryness; the dry mass being treated with boiling water, will leave an insoluble residuum, and may be identified as silica by its grittiness, which is recognized by rubbing it in the capsule with a glass rod. This residuum of silica is then collected on a filter, washed, dried, ignited, and weighed.

17. The proportion of alkali (potash or soda) contained in soap may be easily determined by an alkalimetric assay, as follows:—Take 100 grains of the soap under examination, and dissolve them in about 2,000 grains of boiling water; should any insoluble matter be left, decant carefully the supernatant solution, and test it with dilute sulphuric acid of the proper strength, exactly as described in the article on *Alkalimetry*.

18. The proportion of alkali contained in soap may also be ascertained by incinerating a given weight of the soap in an iron or platinum spoon, capsule, or crucible, treating the residuum with water, filtering, and submitting the filtrate to an alkalimetical assay. This method, however, cannot be resorted to when the soap contains sulphates of alkalies, because the ignition would convert such salts, or a portion thereof, into carbonates of alkali, which, saturating a portion of the test sulphuric acid, would give an incorrect result.

19. The proportion of oil or of fat in soap is ascertained, according to M. Dumas, by adding 100 gr. of pure white wax, free from water, to the soap solution in which the proportion of alkali has been determined, as just said, and heating the whole until the wax has become perfectly liquid and has combined with, or taken up the oil or fat which was separated by the test sulphuric acid. The whole is then allowed to cool, and the cake of wax obtained is removed and weighed; the increase above 100 grains (the original weight of the wax) indicates, of course, the quantity of grease, fat, or oil contained in the soap. The addition of wax is necessary only when the fatty matter of the soap is too liquid to concrete well on cooling. Good mottled soap ordinarily contains from six to eight per cent. of soda; from 60 or 70 per cent. of fatty acids and rosin; and from 30 to 34 per cent. of water.

20. The nature of the fat, of which a given sample of soap has been made, is more difficult to detect, yet by saturating the aqueous solution of the mass under examination with tartaric acid, collecting the fatty acids which then float on the surface, and observing their point of fusion, the operator, at any rate, will be enabled to ascertain whether the soap under examination is identical with the sample from which it may have been purchased, and whether it was made from tallow, or from oil, &c.

21. When the fatty acids which have been isolated by decomposing the soap with sulphuric or hydrochloric acid, as

above said, are heated in a small capsule, the odour evolved is often characteristic, or at least generally gives a clue to the nature of the fats or oils from which the soap has been made. This odour is often sufficiently perceptible at the moment when the aqueous solution of the soap is decomposed by the acid poured in.

22. Properly made soap should dissolve completely in pure water; if a film of fatty or oily matter is seen to float on the surface, it is a proof that all the fat is not saponified. Another test is, that the fatty or oily acid, separated by treating the soap with hydrochloric acid, should be entirely soluble in alcohol.

23. Soft soaps, as we said, are combinations of fats or oils with potash; or rather are solutions of a potash-soap in a ley of potash, and they therefore always contain a great excess of alkali, and a more or less considerable proportion of water; they contain also a certain quantity of chlorides, of sulphates, and all the glycerine which the saponifying process has set free. The use of soft soap is chiefly used in this country for fulling, and for the scouring or cleansing of woollen stuffs; in Belgium, Holland, and Germany, it is used also for washing linen, which thereby acquires a most disagreeable odour of fish-oil, the latter substance being generally employed in the manufacture of that soap. The most esteemed soft soap, however, is that made from hempseed-oil, which imparts to the soap a greenish colour; but this much-prized colour is generally artificially given to soft soap made of other oil, and which has a yellow colour, by means of a little indigo finely pulverized and previously boiled for some time in water.

24. Soft soap is analyzed exactly as hard soap; good soft soap should not contain more than from 45 to 55 per cent. of water.

S O Y.

1. Soy is a culinary preparation produced from a small bean, obtained from the *Dolichos soja*, from which a sauce is

made in Japan and in China, and which is principally eaten with fish.

2. Genuine soy, however, is somewhat a rarity in England ; most of that which is sold in bottles under that name is spurious, and consists altogether of treacle, water, salt, and a little flour, to give it greater consistence, but which latter substance is often omitted.

3. Genuine soy has a peculiar flavour ; it should neither be too salt, nor too sweet, the colour should be brown, and when shaken in a glass, it should leave on the surface a coating of a transparent, bright, yellowish-brown colour.

SPATHOSE IRON.—See *Iron Ores*.

SPEISS.

1. Speiss is an arsenio-sulphuret of nickel, which is found at the bottom of the crucibles in which smalt is prepared. Its composition is generally as follows :—

Nickel	.	.	.	.	49
Arsenic	.	.	.	.	38
Sulphur	.	.	.	.	8
Cobalt, copper, and antimony	.	.	.	.	5
					100

2. Nickel is sometimes extracted in this country from speiss ; but in Germany, speiss is always treated for nickel for the manufacture of German silver.

3. The quantitative determination of the constituents of speiss may be effected in the following manner :—

4. The mass is first reduced into powder, and roasted as completely as possible with charcoal, in order to volatilize the arsenic ; speiss being very fusible, the mass should be

diligently stirred during the roasting, and if it fuses, which frequently happens, the mass should be pulverized again, and again roasted in conjunction with charcoal. After having eliminated the arsenic as completely as possible, the washed mass is dissolved in aqua regia, and evaporated to dryness. Water is poured upon the dry mass and filtered. A stream of sulphuretted hydrogen is then passed through the solution, and the analysis proceeds exactly as we described for the analysis of Kupfer Nickel. (See the article on *Kupfer Nickel*.)

SPELTER.—See *Zinc*.

SPIRITS.—See *Alcohol*. *Brandy*.

SPIRITS OF HARTSHORN.—See *Ammonia*.

SPIRITS OF SALT.—See *Hydrochloric Acid*.

SPIRITS OF WINE.—See *Alcohol*.

STEEL.

1. Steel is a combination of iron with carbon, in which the latter substance does not form more than the one hundred thousandth part of the weight of the mass. The proportion of carbon, however, is more considerable in steel than in the ordinary iron of commerce, but less so than in cast iron; traces of silicium and of phosphorus are also found in it, and it may further contain small quantities of manganese, of aluminum, and sometimes even traces of arsenic.

2. The ores of iron which contain manganese are pre-eminently applicable to the manufacture of steel. In 1839,

Mr. Heath took a patent for the introduction of a small portion (1 per cent. or less) of carburet of manganese into the crucible with the broken bars of blistered steel ordinarily used, and he found that the cast steel obtained after fusion yielded steel of a superior quality, which had acquired the peculiar and valuable property of being weldable to itself, and to wrought iron.

3. The best steel may be recognized by the following criteria :—

4. Good steel, tempered at a low heat, should become very hard ; its hardness should be uniform through all its mass ; it should resist a smart blow without breaking, and should lose its hardness only by exposure to a strong heat ; it should weld easily, and without cracking, and its fracture should present a fine, equal, and close grain.

5. The analysis of steel is performed like that of cast iron, to which the reader is referred.

6. The composition of steel, according to Vauquelin and Gay Lussac, is as follows :—

Blistered Steel, according to Vauquelin.				Cast Steel, according to Gay Lussac.			
Carbon.....	0.79	0.68	0.63	0.62	0.65	0.65	0.94
Silicium	0.15	0.12	0.11	0.03	0.00	0.04	0.08
Phosphorus.....	0.34	0.82	0.52	0.03	0.08	0.07	0.11
Iron.....	98.72	98.38	97.74	99.32	99.27	99.24	98.87
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

STICK LAC.—See *Shellac*.

SUBACETATE OF COPPER.—See *Acetate of Copper*.

SUBCHLORIDE OF MERCURY.—See *Calomel*.

SUCCIN.—See *Amber*.

SUCCINATE OF AMMONIA.

1. Succinate of ammonia is a salt which is in white crystals, unalterable in the air : the price of this substance being high, it is often adulterated with *tartaric acid*, or, according to Berzelius, it is sometimes altogether imitated by a mixture of tartaric acid and of rectified oil of amber. This fraud is easily detected by dissolving a portion of the salt in question in water, and then adding to its solution, first, a drop of a persalt of iron, and then caustic ammonia. If the liquor contains tartaric acid, the ammonia will fail in producing a reddish-brown precipitate of peroxyde of iron. The adulteration may also be detected by gently igniting a portion of the salt ; pure succinate of ammonia volatilizes, and leaves only a trifling residuum of charcoal, whilst tartaric acid intumesces and leaves a bulky, porous charcoal, and emits, during ignition, the characteristic odour of burnt bread.

SUCCINIC ACID.

1. Succinic acid is usually extracted from amber, by subjecting the latter substance to dry distillation ; but it may also be obtained by concentrating the mother water resulting from the action of nitric acid upon wax, or upon stearic acid.

2. Pure succinic acid is in white, nacreous spangles, soluble in water, especially in hot water, and the solution deposits crystals in cooling ; it is less soluble in alcohol, and scarcely soluble at all in ether.

3. Succinic acid is often adulterated with *tartaric acid*, *bisulphate* or *binoxalate of potash*, and with *sal ammoniac*.

4. The presence of *tartaric acid* is detected by igniting a portion of the acid ; if tartaric acid is present, a carbonaceous residue will be left, whilst pure succinic acid, on the contrary, evaporates completely when exposed to a red heat, upon a strip of platinum foil. If pure succinic acid be mixed with a solution of a persalt of iron, and an excess of aqueous ammonia be further added, a reddish-brown precipitate of peroxyde of iron will be produced ; not so, however, if tartaric acid, or another non-volatile organic acid is present, at least in sufficient quantity, the solution of the persalts of iron not being precipitable by ammonia from solutions which contain non-volatile organic acids. The admixture of tartaric acid may also be detected in succinic acid by dissolving a portion of the sample in water, saturating the acid with ammonia, and then testing with a solution of chloride of calcium, which will then produce an abundant white precipitate of tartrate of lime ; whilst, if the succinic acid is pure, no precipitate will be produced. If oxalic acid or a soluble oxalate is present, chloride of calcium produces a precipitate also.

5. If the succinic acid under examination contains any bisulphate or binoxalate of potash, a residuum will also be left after exposure to a red heat, which residuum being dissolved in water, may be identified as such, by dividing the solution into two portions, and adding to one of the portions a solution of chloride of barium, which will then produce a precipitate of sulphate of baryta, which may be collected on a filter, washed, ignited, and weighed. If a solution of sulphate of lime, being added to the second portion, produces also a white precipitate, it is oxalate of lime, which may be collected on a filter, washed, dried, and ignited. Ignition converts the oxalate of lime so produced into carbonate of lime, in which state it is weighed. 117 grains of sulphate of baryta represent 146 grains of bisulphate of potash (crystallized) ; 50 grains of carbonate of lime represent 120 grains of binoxalate of potash.

6. Whether the succinic acid under examination contains sal ammoniac or not, is ascertained by triturating a portion of the salt with potash ; if sal ammoniac is present, an odour of ammonia will be evolved, especially if a little water be added whilst triturating. If the quantity of ammonia thus evolved is too small to be detected by the odour, a glass rod, moistened with pretty strong, but not fuming muriatic acid, is to be held at the surface of the mixture, when white fumes will immediately be observable.

SUGAR.

1. The sugar universally used in England is cane-sugar, which, as every body knows, is extracted from the sugar-cane (*arundo saccharifera*), which is raised in the English colonies. The manufacture of this important article is briefly as follows :—The juice of the cane is first boiled with lime in boilers, where it is converted into syrup, which, when sufficiently concentrated, is transferred to coolers, and thence into upright casks, perforated at the bottom, placed over a tank or cistern, into which the syrup which has not crystallized percolates, whilst the sugar remains in the casks in the state of *coarse* or *moist sugar*. From this *coarse* or *moist sugar*, white or loaf-sugar is obtained by the refiner by various processes, which it is not the object of this work to detail.

2. Moist or coarse sugar is often adulterated with *sand*, *plaster*, *chalk*, *potato-flour*, and other feculas, but the principal sophistication is with *starch* or *potato-sugar*, (grape-sugar, glucose). The manufacture of starch or grape-sugar, has been within the last few years so much improved, that it is by no means easy to distinguish it from ordinary moist sugar, especially from that which comes from the East Indies. Starch-sugar is sometimes mixed with good muscovado, or

coarse cane-sugar, and sold to the refiner and grocer as genuine cane-sugar; but the fraud is more generally, and almost exclusively practised by the retailing grocer; the public, and more especially the poorer classes, being thus cheated to an almost incredible extent; at the same time, it should be observed, that, as it is a practice almost without exception, amongst retailing grocers, to sell sugar at cost price, and even occasionally under cost price, the loss is to a certain extent made up by the adulterations above alluded to. This admixture of grape or potato-sugar is not confined to moist or coarse sugar; pounded white sugar often contains considerable quantities of it, sometimes to the extent of 30 per cent.

3. The presence of grape-sugar in cane-sugar may, however, be detected in various ways:—

4. *M. Chevallier's process.* Take of distilled water 300 grains, sugar 150 grains, caustic potash eight grains, and introduce the whole into a tube of suitable capacity and closed at one end, or in a small flask, and boil.

5. If the sugar is pure cane-sugar, no sensible change of colour will take place, or the solution will only take a green tinge; but if grape-sugar be present, the solution will assume a brown colour, more or less intense, in proportion to the quantity of grape-sugar present. M. Chevallier says, that with a little experience that quantity may be approximatively determined. At any rate, it is a test of the presence of that substance, and, according to M. Kuhlman, if the sugar contains from two to three per cent. of grape-sugar, the change of colour of the solution is quite distinct.

6. *Trommer's process.* A more delicate test is that originally contrived by Trommer, by which even so small a quantity as one thousandth part of grape sugar can be detected. When a solution of sulphate of copper mixed with a solution of potash is poured into a solution of sugar, after boiling a few minutes a yellow hydrate of oxyde of copper is deposited. Dr. Ure gives the following directions:—Dissolve a certain

quantity of sulphate of copper (20 grains for example) in a measured quantity of water, and add, in the cold, a solution of caustic potash thereto, until, by testing with turmeric paper, the solution becomes faintly alkaline, which is known by the turmeric paper becoming slightly brown. This forms the test-liquor, which, before using, should be well shaken. If a small quantity of this test-liquor be now added to the aqueous solution of the sugar under examination, and the whole boiled, the solution becomes at first green, and then olive-green, if dextrine is present ; but if it contains grape-sugar, the salt of copper is immediately reduced into the state of orange oxyde of copper ; whilst the solution of pure cane-sugar undergoes no change, or scarcely any change. The proportion of oxyde of copper produced, affords, therefore, a good criterion of the purity of the sugar, and of the extent to which it is adulterated.

7. *M. Barreswill's process* consists in preparing a test-alkaline solution of copper with tartaric acid, by means of which not only the quantity of sugar but of each species of sugar can be determined in any given solution. The experiment is performed somewhat like an alkalimetical assay, that is to say, a given quantity, for example, 1000 grains-measure of the test-liquor are poured into a glass-beaker or capsule, and heated therein to the boiling point ; a known quantity of sugar being dissolved in 10,000 grains-measure of water, 1000 grains-measure, that is one-tenth part of it, is poured into an alkalimeter, and carefully dropped into the test-liquor in the capsule as long as a precipitate continues to be formed. If only a small quantity of grape-sugar is present, only a yellow cloud of protoxyde of copper appears ; but if that quantity is at all considerable, an abundant reddish precipitate of oxyde of copper is produced. If no grape-sugar is present, no precipitate or cloudiness appears.

8. If now the operator has ascertained beforehand the strength of his test-liquor, that is to say, what quantity of sugar is necessary to reduce the copper contained in the test-

liquor, he has only to read off what number of divisions of the solution of sugar in the alkalimeter has been employed, to know the proportion of glucose it contained.

9. The strength of the test-liquor is ascertained by dissolving, for example, 100 grains of pure white sugar in about a pint of water, containing $\frac{1}{40}$ of its weight of hydrochloric acid, boiling the solution for one or two minutes, and adding as much water as may be necessary to bring it to exactly 10,000 grains-measure. The ebullition with hydrochloric acid, as just said, converts the pure sugar into glucose (grape sugar).

10. To prepare the test liquor in question, take 500 grains of pulverized cream of tartar, 400 grains of carbonate of soda, dissolve in five ounces of water, and heat the whole to ebullition; add to the mixture 300 grains of crystallized sulphate of copper reduced to powder, boil, and allow the whole to cool; lastly, add 400 grains of caustic potash, dissolved in four ounces of water, add as much water as will make about one pint, and boil again. This liquor undergoes scarcely any change, provided it be kept in a black bottle, and in the dark.

11. Or, according to M. E. Krantz, take 30 grains of the sugar under examination, dissolve them in about one ounce of distilled water, filter, and add three grains of pure caustic potash (potasse à l'alcohol), and one and a half grain of sulphate of copper, shake the mixture well, and close the vessel containing it air tight. If starch or grape-sugar is present, a red precipitate will be formed after some time, and if in considerable quantity, the copper will be entirely converted into protoxyde within 20 hours. The solution is at the beginning blue or green, it then gradually loses its colour, and at last it becomes colourless and does not contain a trace of copper. Pure cane or beet-root sugar does not yield any red precipitate under the same circumstances, even after a lapse of eight days.

12. If the sugar under examination is a mixture of equal

parts of cane and of potato, or grape sugar, the precipitation is complete within 20 hours. And even with two and a half per cent. of starch-sugar, a slight red precipitate is obtained after 24 hours, but the solution remains coloured after eight days have elapsed. The above tests are applied at the ordinary temperature.

13. The "*Pharmaceutische Central Blatt*," of the 22nd of September, 1847, gives the following process for detecting the adulterations of cane-sugar.

"If syrup of cane-sugar be treated by a boiling hot saturated solution of bichromate of potash, and the whole be then boiled, a violent reaction will take place, which continues even after the vessel has been withdrawn from the fire, and the mixture has then assumed a greenish-yellow colour, owing to a reduction of oxyde of chromium. But if syrup of grape-sugar be treated in the same manner, no such re-action takes place; nay, if the cane-sugar contain from one-eighth to one-third part of grape-sugar, the re-action of the bichromate of potash upon the cane-sugar above related will not take place, the mixture, after the addition of the bichromate of potash, being boiled, will only froth up a little more than if no such addition had been made, but no oxyde of chromium will be reduced, and consequently, no change of colour will be observed, unless the proportion of grape-sugar be less than has been mentioned, but even then, the reaction is far from being as distinct as with pure cane-sugar."

14. Although bichromate of potash is a good test for distinguishing *syrup* of cane-sugar from *syrup* of grape-sugar, this test is altogether incapable of distinguishing one sort of sugar from the other, however concentrated their solutions may be. The two species of sugar may be distinguished from each other by means of solution of nitrate of cobalt, as follows :—

15. If, after having boiled a concentrated solution of cane-sugar with a small quantity of potash, a few drops of solution of nitrate of cobalt is poured in, a purple precipitate will be

produced even after diluting the liquor. With solution of grape-sugar no precipitate is produced by nitrate of cobalt, unless the solution is concentrated, when a dingy-brown precipitate is formed. If the cane-sugar be mixed with grape-sugar the formation of the purple precipitate is prevented.

16. Herzog says that the reaction of bichromate of potash with beet-root-sugar is as violent as with cane-sugar, but that the solution does not become green, as is the case with that of cane-sugar ; but if the proportion of the latter predominate, then the green reaction takes place. The reaction of beet-root-sugar and of cane-sugar with nitrate of cobalt is exactly the same, but sugar of milk behaves like grape-sugar with that re-agent.

17. Cane-sugar is sometimes adulterated with sugar of milk ; this fraud is easily detected by treating the mixture with alcohol, specific gravity 0.852, the cane-sugar is dissolved, but the sugar of milk remains insoluble. Sugar of milk imparts a brick-red colour to arsenic acid.

18. Potato, or grape-sugar, fuses at about 220° Fahr. ; as it cools, it becomes at 150° Fahr. of the consistence of honey, and when cold, it has that of treacle, in which state it remains for a considerable time before it becomes solid again, and its colour remains unaltered, whilst pure cane-sugar requires a heat of 280° Fahr. to fuse, and it then immediately becomes brownish-black, or of a deep chestnut-colour, because it then begins to be charred.

19. Dr. Ure remarks that the specific gravity of a solution of cane-sugar containing 70 per cent. of sugar is 1.342, whilst the solution of grape-sugar of the same specific gravity contains $75\frac{1}{2}$ per cent. of concrete matter, dried at 260° Fahr. and consequently freed from the 10 per cent. of water which it contains in the granular state.

20. Cane-sugar is about $2\frac{1}{2}$ times more sweet than grape-sugar.

SUGAR OF LEAD.—See *Acetate of Lead*.

SUGAR PLUMS.—See *Blanc Mange*.

SULPHARSENIC ACID.—See *Sulphuret of Arsenic*.

SULPHARSENIOUS ACID.—See *ditto*.

SULPHATE OF COPPER.

BLUE COPPERAS. BLUE VITRIOL. ROMAN VITRIOL.

1. Sulphate of copper is met with in commerce in four or eight-sided prismatic crystals of a fine blue colour, slightly efflorescent, inodorous, and having a styptic, metallic, disagreeable taste. The specific gravity is 2.19. The crystals are soluble in 4 parts of cold, and 2 parts of boiling water; the solution reddens litmus paper. The crystals contain 5 equivalents of water (CuO , SO_3 , 5HO), and are completely insoluble in alcohol. Exposed to a dry atmosphere, they effloresce, lose 2 equivalents of water, and become opaque; at 212° Fahr. they retain only 1 equivalent of water, and at a temperature of about 292° Fahr. they become converted into an almost white powder, which is an anhydrous sulphate of copper, but which becomes blue again, by pouring water upon it. Ignition decomposes sulphate of copper completely, and converts it into protoxyde of copper (CuO).

2. The sulphate of copper of commerce is often contaminated, sometimes to a large extent, with sulphate of iron, of zinc, and of magnesia.

3. In order to detect the presence of iron in sulphate of

copper, the operator should dissolve the crystals under examination in water, boil with some nitric acid, and then add to the solution an excess of ammonia. The ammonia at first precipitates both the iron and the copper; but the latter soon redissolves in the excess of ammonia, whilst the peroxyde of iron is left in insoluble reddish-brown flakes, which may be collected on a filter.

4. Supposing, however, that the sulphate of copper under examination contains at the same time sulphate of iron, of zinc, and of magnesia, the best way of detecting the presence, and determining the amount of these impurities, is, perhaps, as follows :

5. Dissolve a weighed quantity of the salt under examination in water, and acidify the solution somewhat strongly with hydrochloric acid; a current of sulphuretted hydrogen is then slowly passed through the acid solution until it smells strongly of the gas; a black precipitate is produced, which is sulphuret of copper, and which should be rapidly collected on a filter, and washed without interruption with water containing some sulphuretted hydrogen. The sulphuret of copper obtained is then dried, so that it may be easily detached from the filter, and it is transferred to a glass-beaker. As the filter still retains small particles of the sulphuret of copper, it should be burnt separately on the cover of a platinum crucible, and the ashes being added to the sulphuret of copper in the glass-beaker, the whole is treated by nitric acid, or aqua regia, until the sulphur, which separates, has acquired a pure lemon-yellow colour. The solution is then filtered, and the protoxyde of copper is precipitated by means of a solution of caustic potash; the whole is moderately boiled, in order to agglomerate the oxyde of copper, which may then be collected on a filter, washed with hot water, dried, ignited in a platinum crucible, which should be kept covered, and after cooling, it is weighed. 40 grains of oxyde of copper represent 80 grains of anhydrous sulphate of copper, or 125 grains of the ordinary crystals.

6. The liquor filtered from the sulphuret of copper, produced by sulphuretted hydrogen, should now be heated until all odour of the gas has disappeared, nitric acid is then poured into it, and the whole is boiled, in order to peroxyde the iron; the acid liquor should now be neutralized with ammonia, and precipitated by succinate of ammonia, exactly as mentioned in the analysis of zinc ores. The liquor filtered from the persuccinate of iron produced should then be treated by hydrosulphuret of ammonia, which, if zinc is present, will produce a white precipitate of sulphuret of zinc, which may be converted into oxyde of zinc, exactly as described in the article on zinc. The liquor which was filtered from the sulphuret of zinc may finally be supersaturated with hydrochloric acid, in order to decompose the hydrosulphuret of ammonia, and the magnesia which is in solution in that liquor is precipitated in the state of bibasic phosphate of ammonia and magnesia ($2 \text{ MgO}, \text{NH}_4\text{O}, \text{PO}_5, + 12 \text{ aq.}$), by means of a solution of phosphate of soda with addition of ammonia. This precipitate should be collected on a filter, washed, but not too long, because it is not quite insoluble in water, or else the water used for washing should be mixed with some ammonia. The precipitate should be left at rest for several hours (about twelve hours), because it takes a long time to settle; after which it may be collected on a filter, as above said, washed, thoroughly dried, and gradually submitted to an intense heat, in a covered platinum crucible. After cooling, it is weighed. 1 grain of pyrophosphate of magnesia contains 0.36637 grain of magnesia.

SULPHATE OF MAGNESIA.

EPSOM SALTS. SEDLITZ SALT.

1. Sulphate of magnesia is a combination of sulphuric acid and magnesia, which is met with in commerce in rectangular

four-sided prismatic crystals, or in masses composed of a great number of small needles, white, inodorous, and of a bitter disagreeable taste. Sp. gr. 1.66. Sulphate of magnesia is soluble in its own weight of cold water, and is insoluble in alcohol. It effloresces in the air, and when heated it fuses in its own water of crystallization. The quantity of the water of crystallization of sulphate of magnesia varies according to the temperature at which it is made to crystallize; hydrates of this salt may be obtained containing one, two, five, six, seven and twelve equivalents of water of crystallization. When sulphate of magnesia is left to crystallize at 60° Fahr., it ordinarily contains seven equivalents of water.

2. Sulphate of magnesia is often adulterated with sulphate of soda, nay, this latter salt is sometimes altogether sold under the name of sulphate of magnesia. The two salts may be easily distinguished from each other, because sulphate of soda crystallizes in long six-sided prisms more transparent than those of sulphate of magnesia, and more efflorescent; its taste is fresh, saline, and somewhat bitter, but less disagreeable than that of sulphate of magnesia; its sp. gr. is 1.349. Lastly, a solution of carbonate of potash or of soda, poured into a solution of sulphate of soda, produces no precipitate whatever; whilst an abundant, bulky, white precipitate is immediately produced by that reagent in one of sulphate of magnesia.

3. Nothing is therefore more easy than to distinguish these two salts from each other in an isolated state; but when they are mixed together, the operator may detect it by drying a small portion of the sample, and heating it before the blow-pipe, to the flame of which it will immediately impart a strong yellow colour. If now the operator wishes to ascertain the proportion or extent of the adulteration, he should proceed as follows:—

4. Take a certain portion of the salt under examination, dry it at a steam-heat until reduced into a white powder, and

expose this white powder, which is the effloresced sulphate, to a *moderate* red heat, in order to expel completely the water of crystallization. Take 60 grains of the ignited sulphate, and dissolve them in pure distilled water, add then an excess of solution of carbonate of potash or of soda, and boil; allow the liquor to become cold, and collect the precipitated carbonate of magnesia upon a filter, wash it carefully with boiling water (see filtering apparatus, page 455), but not too long, since it is not completely insoluble in even hot water, dry it, and ignite it strongly for some time, in order to expel the carbonic acid, the residuum is pure magnesia; 60 grains of sulphate of magnesia, previously exposed to a moderate red heat, as above said, should yield 20 grains of pure magnesia, or each grain of sulphate of magnesia should yield 0.34015 grain of pure magnesia. If, therefore, the operator subtracts from the total weight of the salt under examination, and which has been subjected to experiment, the amount of sulphate of magnesia indicated by the precipitate above alluded to, the difference will, of course, show the weight of the sulphate of soda which has been added. If, however, the operator wishes to determine the quantity of sulphate of soda by actual experiment, he may do so by dissolving in distilled water a given weight of the suspected salt, and pouring into this solution a quantity of chloride of barium, just sufficient to precipitate all the sulphuric acid in the state of sulphate of baryta, but avoiding to use an excess of chloride of barium; that is to say, the chloride of barium should be added very cautiously as long as it continues to produce a precipitate or a turbidness, but no farther. The liquor should then be warmed and left at rest until all the precipitate has settled; it is then collected on a filter, washed, and the filtrate is cautiously evaporated to dryness. The dry residuum, which consists of chloride of sodium and of chloride of magnesia, is allowed to become cold, and it is then treated in the cold with rectified alcohol, which will dissolve the chloride of magnesium, but will leave the chloride of

sodium in an almost insoluble state. From the weight of the chloride of sodium left, that of the sulphate of soda may be calculated; each grain of chloride of sodium represents 0.53010 grain of soda, and, consequently, 1.192725 grain of anhydrous sulphate of soda. The alcohol employed should be highly rectified, for although chloride of sodium is almost insoluble in anhydrous alcohol, it is dissolved in large quantities in spirits of wine.

SULPHATE OF POTASH.

SAL DE DUOBUS.

1. This salt crystallizes in short six-sided prisms, terminated by hexaedral pyramids; the crystals are anhydrous, hard, white, unalterable by exposure, their taste is slightly bitter, they decrepitate strongly when heated. When strongly ignited they fuse, but are not decomposed. Their sp. gr. is 2.4073.

2. According to M. Gay Lussac.

100 parts of water at 61° F. dissolve 10.5 parts of sulphate of potash.

do.	120.2	do.	16.9	do.
do.	215	do.	26.3	do.

3. Sulphate of potash is completely insoluble in alcohol.

4. The sulphate of potash of commerce is often contaminated by *sulphate of zinc, of iron, of copper, of magnesia, of lime*, and sometimes by *bisulphate of potash*.

5. The presence of *sulphate of zinc* is detected by dissolving a portion of the salt in water, acidifying with a little nitric acid, and supersaturating with ammonia. If *iron* is present, reddish-brown flakes of peroxyde of iron will be precipitated, and should be separated by filtering. If *copper* is present, the solution will have a blue tinge. Admitting,

however, that the salt under examination contains no other impurities than sulphate of zinc, the solution will remain perfectly clear after the addition of the ammonia ; that is to say, at first the ammonia may determine a white precipitate, which, however, will be immediately redissolved by an excess of the re-agent ; if it is not redissolved it is a proof that some other base is present, and the liquor must be filtered. However this may be, if hydrosulphuret of ammonia, being added to the clear, colourless, strongly ammoniacal liquor, produces a white precipitate or cloudiness, insoluble in an excess of hydrosulphuret of ammonia, it is certainly sulphuret of zinc. If the sulphuret of zinc so produced is in sufficient quantity, it may be collected on a filter, redissolved in hydrochloric acid, boiled until all odour of sulphuretted hydrogen has disappeared, filtered, and reprecipitated as carbonate of zinc by carbonate of potash or of soda, with the precautions which are indicated farther on in the article on *Zinc* and *Zinc Ores*.

6. If the solution contains the slightest trace of iron, the precipitated sulphuret of zinc produced by hydrosulphuret of ammonia, instead of being white, may be gray, or blackish, or interspersed with black flakes, or altogether black, according to the quantity of iron present.

7. If *iron* is present, it will have been precipitated from the solution by ammonia, in the state of peroxyde of iron, as we said, which may be collected on a filter, washed, dried, ignited, and weighed. If both iron and zinc are present, they may be separated by means of a solution of neutral succinate of ammonia, or by carbonate of baryta, exactly as is described in the article on *Zinc* and *Zinc Ores*.

8. If *copper* is present, the addition of ammonia will have produced a blue tinge or colour as above said ; or if in too small quantity to be thus detected, the operator may test the aqueous solution of the salt, to which no ammonia has been added, with ferrocyanuret of potassium, which will then produce a reddish-brown precipitate of a crimson tinge. If the precipitate or colour is blue, it is due to the presence of iron.

9. Generally, only a trace of these impurities is indicated by the above tests.

10. If magnesia alone is present, a portion of the solution of the salt, to which no ammonia has been added, being tested with caustic potash, will produce a white precipitate of hydrate of magnesia. Or else the solution of the salt may be mixed with an excess of solution of sal-ammoniac, and then tested with a solution of phosphate of soda and ammonia, which will immediately produce a white precipitate of ammonia-phosphate of magnesia.

11. If *lime* is present, the solution of the salt being tested with a solution of binoxalate of potash, or of oxalate of ammonia, will produce a white precipitate, or be rendered turbid.

12. The presence of *bisulphate of potash* is detected, because the salt, instead of being neutral to test-papers, reddens blue litmus paper. The salt should be drenched with water before testing with litmus paper.

13. Supposing, however, which is not probable, that all these impurities are present at the same time, they may be detected as follows :—

14. 1°. Dissolve the salt in water, acidify the solution with hydrochloric acid, and pass a stream of sulphuretted hydrogen through it until it smells strongly of the gas. A black or dark brown precipitate is produced—it is sulphuret of copper. Confirm, by collecting the black precipitate on a filter, re-dissolve it in nitric acid, and supersaturate the nitric acid solution with ammonia ; a blue colour is produced. Copper is present.

15. 2°. To the liquor filtered from the sulphuret of copper, add an excess of sal-ammoniac, and then ammonia, and whether a precipitate is produced or not, add an excess of hydrosulphuret of ammonia.

16. If a white precipitate only has been produced, it is sulphuret of zinc ; if the precipitate is gray or black, zinc and iron may be present. Collect the precipitate on a filter, and

keep the filtrate for further examination ; wash the precipitate and redissolve it in nitric acid, and supersaturate the solution with ammonia. If a reddish-brown precipitate is produced, insoluble in an excess of ammonia, it is peroxyde of iron. Confirm, by redissolving it in a small quantity of hydrochloric acid, so that the solution may be as neutral as possible, and test a portion of this with solution of ferrocyanuret of potassium. A blue precipitate is formed—test another portion with tincture of galls, a black colour is produced. Iron is present.

17. If the liquor filtered from the precipitate of peroxyde of iron produced by ammonia, and which is strongly ammoniacal, clear and colourless, being now tested by hydrosulphuret of ammonia, yields a white precipitate, it is sulphuret of zinc. The white precipitate which hydrosulphuret of ammonia produces in a clear, colourless, strongly ammoniacal or alkaline solution, can hardly be anything else than sulphuret of zinc.

18. 3°. The solution which was filtered from the precipitate produced by ammonia and hydrosulphuret of ammonia, and which was kept for further examination, should now be boiled with hydrochloric acid until all odour of sulphuretted hydrogen has disappeared ; filter, if necessary, and boil the filtrate with an excess of carbonate of ammonia mixed with ammonia. If a precipitate is produced, it is carbonate of lime. Collect the precipitate upon a filter, redissolve it in a small quantity of hydrochloric acid, neutralize with ammonia, and test with oxalate of ammonia. A white precipitate is produced. *Lime* is present.

19. If to the liquor filtered from the precipitate produced by boiling with carbonate of ammonia mixed with ammonia, the further addition of phosphate of soda produces a white precipitate, it is magnesia.

SULPHATE OF QUININE.

1. Sulphate of quinine is prepared principally from the yellow or Calysaya bark (see *Peruvian bark*), by the action of sulphuric acid upon quinine.

2. The neutral sulphate of quinine is in small, silky, flexible tufts or needles, somewhat resembling asbestos, and has an excessively bitter taste, sparingly soluble in cold water (1 part in 740 of cold water), soluble in 30 parts of boiling water, very soluble in alcohol, especially in hot alcohol, and in ether. This salt effloresces by exposure, when heated it fuses like wax, and at a temperature of 212° Fahr. it becomes phosphorescent, especially by friction.

3. The solution of sulphate of quinine (when not too dilute) is precipitated by potash, soda, and ammonia, in the state of a flocculent white precipitate, which is hydrate of quinine, which is only very sparingly soluble in an excess of the precipitant. An excess of ammonia, however, redissolves partially the precipitate.

4. Tartaric, oxalic, and gallic acids, and the soluble salts of these acids, and also the infusion of galls, produce in the solution of sulphate of quinine a precipitate which is soluble in an excess of acid.

5. Bicarbonate of soda (according to Dr. Fresenius) immediately precipitates a concentrated solution of sulphate of quinine, and in dilute solutions a precipitate is produced by that re-agent in the course of a quarter of an hour, especially by stirring the liquor briskly.

6. This very important article is often adulterated by an admixture of *gum, sugar, starch, chalk, sulphate of baryta, boracic acid, stearine, sulphate of cinchonine, salicine, &c.*

7. These frauds may be recognized in the following manner:—

8. If the sulphate of quinine under examination contains any earths, such as chalk, sulphate of lime, &c., their pre-

sence may be detected by incinerating a portion of the sample, which will leave the earths in the state of fixed ashes, the weight of which may then be directly ascertained. Pure sulphate of quinine should not leave a trace of residue; or, as sulphate of quinine is soluble in alcohol, a portion of the suspected sulphate of quinine may be treated by this menstruum, which will take up the sulphate of quinine (and of cinchonine, also the salicine if present), but will leave all the earthy impurities, stearine, gum, and starch in an insoluble state; these impurities may then be separated by filtering, and weighed.

9. If any *stearine*, or stearic acid, has been mixed with sulphate of quinine, treat a portion of the sample with water acidified with sulphuric acid; the sulphate of quinine will dissolve, and the stearine will be left in an insoluble state *floating* on the surface of the liquid; if heat be now applied, the stearine will agglomerate into small transparent drops, which, on cooling, become solid and opaque.

10. The presence of *sugar* may be detected by the odour of burnt sugar, which is evolved on burning a portion of the suspected article upon a strip of platinum foil. A more certain method, however, consists in dissolving a given weight of the sulphate of quinine in water, and adding baryta thereto, which will precipitate both the sulphuric acid and the quinine. The liquor should then be filtered, or a current of carbonic acid should be passed through the filtrate, in order to precipitate the excess of baryta in the liquor. The precipitate formed being separated by filtering, the sugar alone remains in solution in the liquor, and may then be easily detected by its sweetness, especially after concentrating the filtrate.

11. The presence of *sugar* and of *gum* may also be detected by dissolving a given weight of the sample in water, and adding carbonate of potash, which precipitates the quinine (and cinchonine); the precipitate may be collected on a filter, dried, and weighed. The sugar and gum remain in solution

with the sulphate of potash produced from the decomposition of the carbonate of potash employed, and with any salicine that may be present. By evaporating the solution, the presence of sugar will be recognized by the sweet taste of the solution—(if bitter, salicine is present, and may be detected, as will be shown presently.) The solution should now be evaporated to dryness at a gentle heat, and the residuum being treated with spirits of wine, the sugar will be dissolved, but the *gum* and sulphate of potash will remain in an insoluble state. Filter in order to separate the sugar, and pour hot water on the insoluble residuum, which will then be redissolved; test that aqueous solution with persulphate of iron; gum, if present, will at once be precipitated in the form of a yellow gelatinous precipitate.

12. *Starch* may be detected by boiling a portion of the sample with water, and allowing the whole to become quite cold. Test the *cold* decoction with aqueous solution of iodine, a blue or nearly black colour is produced; starch is present.

13. All *organic substances, starch, gum, sugar, stearine, &c.*, mixed with sulphate of quinine, may be readily detected by pouring a few drops of concentrated sulphuric acid upon two or three grains of the suspected sulphate, previously placed in a small porcelain capsule. The pure sulphate of quinine is immediately dissolved, but the *starch, gum, or sugar* will be charred, and the stearine left in an insoluble state; but even the stearine becomes charred by applying heat, whilst sulphate of quinine is not altered by the treatment which converts it into bisulphate of quinine.

14. If *salicine* be present, the addition of concentrated sulphuric acid, as above said, will produce a deep blood-red colour. This property of being coloured red by sulphuric acid, belongs also to other bitter principles; and, moreover, we should remark that this re-action takes place only when the proportion of salicine, mixed with the sulphate of quinine is somewhat considerable; for when under 10 per cent.

a brown colour only is produced by treatment with concentrated sulphuric acid, just as if an ordinary organic matter was present. M. Pelletier directs, to dissolve the suspected sample in six times its weight of concentrated sulphuric acid, and then to dilute the whole with 12 parts of water, which will precipitate the salicine in a colourless state, after which it may then be identified by the red colour which is produced by treatment with concentrated sulphuric acid, as above mentioned; or, a portion of the sample may be dissolved in water, filtered if needful; hydrochloric acid is then added, and the mixture is boiled for some time. If a precipitate is produced, it is salicine; collect it on a filter, and confirm, by treatment with concentrated sulphuric acid, as just said.

15. The presence of *sal ammoniac*, or other *ammoniacal salts*, is detected in sulphate of quinine by the odour of ammonia, which is evolved when a portion of the sample is triturated with caustic potash.

16. Lastly; to detect a mixture of *sulphate of quinine* with *sulphate of cinchonine*, dissolve a portion of the suspected salt, and add an excess of ammonia; add ether to the whole, and shake vigorously; quinine, being soluble in ether, is taken up, whilst cinchonine, being insoluble in this menstruum, may be separated by filtering.

17. Concentrated sulphuric acid at first dissolves cinchonine into a colourless liquid, but on applying heat, it becomes brown, and then black, like the other organic substances before mentioned.

SULPHATE OF ZINC.

WHITE VITRIOL. WHITE COPPERAS.

1. Sulphate of zinc is a combination of one equivalent of sulphuric acid with one equivalent of oxyde of zinc, and seven equivalents of water. It is in colourless, right rhombic crystals,

unalterable, or slightly efflorescent in the air; inodorous, with an acid, styptic, metallic taste, soluble in $2\frac{1}{2}$ times its weight of water at 60° , and in its own weight of boiling water. It is insoluble in alcohol; the specific gravity of the crystals is 1.912.

2. The sulphate of zinc of commerce, however, is often found in white, sometimes crystalline, sometimes amorphous and compact masses or cakes, from its having been cast into moulds after having been melted in its water of crystallization. It is generally obtained by roasting blende (sulphuret of zinc), and it contains, ordinarily, some *magnesia*, traces of *iron* and of *copper*. Sulphate of zinc is also obtained from the action of sulphuric acid upon the zinc of the galvanic batteries now extensively employed in electro-plating.

3. Pure sulphate of zinc should be completely soluble in water; ammonia being added to the solution, produces at first a white precipitate, but which an excess of ammonia should completely re-dissolve.

4. The presence of *iron* is detected by dissolving a portion of the sample, and adding an excess of ammonia, which will produce reddish-brown flakes of peroxyde of iron. In order to ascertain the quantity of the iron, a weighed portion of the salt should be dissolved in water, and acidified with hydrochloric acid, and an excess of solution of sal-ammoniac added; ammonia should now be carefully poured in until a few flakes of peroxyde of iron begin to appear, and the precipitation of the iron is completed by means of a solution of neutral succinate of ammonia, which produces a bulky precipitate of persuccinate of iron, which may then be collected on a filter, dried, ignited, and weighed as peroxyde of iron.

5. The liquor filtered from the peroxyde of iron may then be treated by hydrosulphuret of ammonia, and the analysis proceeds exactly as described in the article on *Zinc* and *Zinc Ores*.

6. When only a trace of iron exists, ammonia may fail in

showing it ; but, in that case, the precipitate produced by hydrosulphuret of ammonia, instead of being white, will be gray or black. A trace of iron may also be detected by dissolving a portion of the sample in water, adding nitric acid, and boiling, neutralizing the acid, as near as possible, with ammonia, and then testing with infusion of galls, which will produce a black colour (ink) if iron be present.

7. If *copper* is present, a slight excess of ammonia being poured in the solution of the salt under examination will produce a beautiful blue colour ; and, moreover, the solution of the salt, being first acidified with hydrochloric acid, and then treated by a stream of sulphuretted hydrogen, will produce a black precipitate. If only a trace of copper is present, the precipitate, instead of being black, is dark brown.

8. If *magnesia* is present, the liquor filtered from the sulphuret of zinc precipitated by hydrosulphuret of ammonia, being tested with phosphate of soda, will produce a precipitate, which is a double phosphate of magnesia and ammonia.

SULPHUR.

BRIMSTONE.

1. Sulphur is a simple body which is met with in commerce in *amorphous masses*, it is then called *massive* or *native sulphur* ; in rolls about one inch in diameter, and five or six inches long, it is then called *stick* or *roll sulphur* ; and in powder, "*flowers of sulphur*," or *sublimed sulphur*.

2. The rough sulphur, in square or oblong blocks, or in amorphous masses, always contains variable quantities of impurities, which, however, are generally in too small proportions to prove materially objectionable for practical purposes. The principal impurities alluded to are, *sand* or *earthy matter*, *oxyde of iron*, *sulphuret of iron*, *carbon*, *sulphate* and

carbonate of zinc, sulphate of lime, sulphuret of arsenic, alumina, magnesia, &c.

3. Pure sulphur being entirely volatilizable by heat, the purity of the article may at once be approximatively ascertained by igniting a given weight of the sample in a platinum crucible; the sulphur volatilizes, whilst the sand, earthy matter, and other fixed impurities are left behind, and may be weighed.

4. The purity of sulphur, however, can *only* be *approximatively* judged from the weight of these impurities, because by this treatment, the sulphurets which are mixed with the sample are roasted, and abandon, if not all, at least, a portion of their sulphur. It is therefore better, if greater accuracy is required, to boil the sulphur, previously pulverized, with fifteen times its weight of spirits of turpentine, which will dissolve all the sulphur, which should be decanted whilst hot, and leave the impurities behind.

5. Rough sulphur contains generally from 7 to 10 per cent. of earthy matter, and sometimes considerably more, but good Sicilian sulphur should not contain more than 3 per cent. of impurities, and sometimes these do not exceed $\frac{1}{2}$ per cent.

6. It is asserted that the article known as precipitated sulphur, or *lac sulphur*, is sometimes adulterated with even as much as 95 per cent. of sulphate of lime. This is hardly credible; at any rate, nothing is easier to test than such an impurity, for by ignition the whole of the sulphur will evaporate, and the sulphate of lime will be left behind.

7. *Sulphur lotum* are the flowers of sulphur which have been washed, in order to remove a small quantity of sulphurous acid, which is formed during the sublimation of sulphur. Washed flowers of sulphur are distinguished from those which have not been washed, because, on pouring boiling water on the latter, the filtering liquor reddens litmus paper, and produces a white precipitate with solution of chloride of barium.

SULPHURET OF ANTIMONY.

ANTIMONIUM CRUDUM. CRUDE ANTIMONY.

1. The sulphuret of antimony of commerce is in masses which consist of shining crystalline needles of a deep steel gray colour which soil paper, and which yield a black powder by trituration, in which state it is often sold. The specific gravity of sulphuret of antimony is 4.5 or 4.62. Heated in the air it fuses with the greatest facility, and disengages sulphurous acid, but if heated out of the contact of the air it does not undergo decomposition. It is insoluble in water, soluble in hydrochloric acid under disengagement of sulphuretted hydrogen.

2. Sulphuret of antimony is often contaminated by *sulphuret of iron, of lead, of copper, of arsenic.*

3. The presence of these impurities may be detected in the following manner. If the sample is not already in powder, it should be pulverized and boiled in aqua-regia, until the sulphur separates in lumps of a perfectly yellow colour; the solution is filtered into a flask, and when cold an excess of ammonia is then added, which produces an abundant precipitate. An excess of hydrosulphuret of ammonia in maximum of sulphur (that is, hydrosulphuret of ammonia in which washed flowers of sulphur have been dissolved), is further added, and the flask being corked up, the whole is left at rest in a warm place for twelve hours. If a black residuum is left insoluble in the excess of hydrosulphuret of ammonia, the operator may conclude that the sulphuret of antimony operated upon contained *iron, lead, or other metals.* If, however, copper was present, the supernatant liquor, after supersaturating with ammonia previous to the addition of the hydrosulphuret of ammonia, had a blue colour. If much *lead* was present, the solution of the sulphuret of antimony must have produced a white precipitate of sulphate of lead, which will have been collected with the sulphur on the filter; the

presence of lead may, however, be easily recognized by moistening the insoluble portion on the filter, and previously washed, with hydrosulphuret of ammonia, which, in that case, will turn it black.

4. The sulphuret of antimony which was dissolved by hydrosulphuret of ammonia, may be contaminated by sulphuret of arsenic, which is soluble also in that re-agent, and therefore the solution should be diluted with water, and boiled with an excess of acetic acid, which will re-precipitate both sulphurets mixed with sulphur. The precipitate so produced by acetic acid should be collected on a filter, and mixed with three times its bulk of a mixture of equal parts of nitrate of potash and of carbonate of soda, and dried at a gentle heat. Another portion of the same mixture of nitrate of potash and of carbonate of soda is then to be fused in a porcelain crucible, and, whilst in a state of fusion, (over an argand spirit-lamp, or over any gas-lamp) mixed with nitrate of potash and carbonate of soda and dried as above said, and then cautiously projected in the porcelain crucible in small portions at a time. The fused mass in the crucible should then be treated by boiling water, filtered, and slightly supersaturated with nitric acid, and boiled. The liquor is then tested by solution of nitrate of silver, and a small quantity of dilute ammonia is then added ; if this produces a light-brown precipitate, it is a basic arseniate of silver, very soluble in nitric acid and in ammonia.

5. The ore of sulphuret of antimony, from which the crude antimony is extracted, is generally contained in a gangue or matrix of quartz, of sulphate of baryta, and of iron pyrites.

6. A sulphuret of antimony, known under the name of *glass of antimony*, is imported from Germany and Holland, which contains *silica*, and is often adulterated with *oxyde of lead*. This fraud is detected by reducing the glass into fine powder, pouring nitric acid upon it, and heating the whole. The solution is then filtered, and the filtrate is tested with a solution of sulphate of soda, which will produce a precipitate

of sulphate of lead, if that metal is present. The precipitated sulphate of lead is collected on a filter, washed with water, acidified with sulphuric acid, dried, and then ignited. If no organic matter is present, and provided the filter containing the sulphate of lead has been burnt separately, and the ashes added to the sulphate of lead produced, its ignition may be performed in a platinum crucible ; but if any portion of the filter is mixed with the precipitate, or if it contains any organic matter, a porcelain crucible must be used, for otherwise a portion of the sulphate of lead might be reduced to the metallic state, which would unavoidably damage the platinum crucible.

SULPHURET OF ARSENIC.

ORPIMENT. TRISULPHURET OF ARSENIC. SESQUISULPHURET OF ARSENIC. SULPHARSENIOUS ACID.

1. Orpiment is found in the native state in China, and East India, Turkey, Bohemia, and Hungary. It is also artificially prepared. The best quality of native orpiment is in masses, consisting of plates of a fine golden colour, intermixed with portions of a vermilion colour ; the inferior qualities are yellow or greenish yellow.

2. Artificially prepared orpiment is a fine yellow powder, which is often adulterated by brick-dust, or by yellow ochre. These impurities are readily separated, and determined by heating a portion of the orpiment, which volatilizes completely, leaving the impurities as a fixed residuum, which may then be weighed.

SULPHURET OF COPPER.—See *Copper Ores*.

SULPHURET OF LEAD.—See *Galena*.

SULPHURET OF ZINC.—See *Blende*.

SULPHURET OF MERCURY.—See *Vermilion*.

SULPHURIC ACID.

OIL OF VITRIOL. VITRIOLIC ACID.

1. Sulphuric acid is a heavy, extremely corrosive, and intensely acid liquid, of an oleaginous consistence, which, when pure, is colourless and odourless. The *sulphuric acid of Nordhausen*, which may be considered as a solution of anhydrous sulphuric in ordinary concentrated sulphuric acid, or as a combination of 2 equivalents of anhydrous sulphuric acid in 2 equivalents of water, has ordinarily a brown or brownish colour; but the ordinary sulphuric acid has frequently that colour also, which in both varieties is probably due to the presence of organic substances which have been charred by the acid. The sulphuric acid of Nordhausen emits fumes in the air, and, of course, is so much the more powerful, as it contains a larger proportion of anhydrous acid, which is disengaged by a gentle heat.

2. The monohydrated or ordinary sulphuric acid which has become brown by exposure, may be decolourized by heating it gently, the carbon of the organic substances being thus converted into carbonic acid.

3. Concentrated sulphuric acid absorbs rapidly the moisture of the air, and accordingly its volume augments considerably by exposure, for it may thus absorb 15 times its own weight of water. The specific gravity of sulphuric acid, in the most concentrated state, never exceeds 1.8485; when it has a density of 1.85, it is a sign of the presence of some impurity. The specific gravity of the most concentrated commercial acid never exceeds 1.847.

4. In taking the specific gravity of sulphuric acid the temperature must be very carefully attended to, on account of the small specific heat of the acid, for the slightest increase of temperature immediately augments the density. Dr. Ure observes, that if the thermometer be lifted out of the acid, the temperature may rise from 15° to 20° on account of the acid which adheres to it, and which absorbs moisture from the atmosphere ; if the thermometer be then plunged into the acid again, the temperature of the whole is raised. This requires, therefore, particular care, since an increase of 10° Fahr., that is to say, from 60° to 70° would bring the specific gravity of the acid from 1.8485 down to 1.7721, which, in fact, would be the gravity of the same acid diluted with 14 per cent. of water.

Table of the Quantity of Oil of Vitriol and Dry Sulphuric Acid in 100 parts of Dilute, at different Densities, by DR. URE.

Liquid.	Sp. Gr.	Dry.	Liquid.	Sp. Gr.	Dry.
100	1.8485	81.54	75	1.6520	61.15
99	1.8475	80.72	74	1.6415	60.34
98	1.8460	79.90	73	1.6321	59.52
97	1.8439	79.09	72	1.6204	58.71
96	1.8410	78.28	71	1.6090	57.89
95	1.8376	77.46	70	1.5975	57.08
94	1.8336	76.65	69	1.5868	56.26
93	1.8290	75.83	68	1.5760	55.45
92	1.8233	75.02	67	1.5648	54.63
91	1.8179	74.20	66	1.5503	53.82
90	1.8115	73.39	65	1.5390	53.00
89	1.8043	72.57	64	1.5280	52.18
88	1.7962	71.75	63	1.5170	51.37
87	1.7870	70.94	62	1.5066	50.55
86	1.7774	70.12	61	1.4960	49.74
85	1.7673	69.31	60	1.4860	48.92
84	1.7570	68.49	59	1.4760	48.11
83	1.7465	67.68	58	1.4660	47.29
82	1.7360	66.86	57	1.4560	46.48
81	1.7245	66.05	56	1.4460	45.66
80	1.7120	65.23	55	1.4360	44.85
79	1.6993	64.42	54	1.4265	44.03
78	1.6870	63.60	53	1.4170	43.22
77	1.6750	62.78	52	1.4073	42.40
76	1.6630	61.97	51	1.3977	41.58

TABLE CONTINUED.

Liquid.	Sp. Gr.	Dry.	Liquid.	Sp. Gr.	Dry.
50	1.3884	40.77	25	1.1792	20.38
49	1.3788	39.95	24	1.1706	19.57
48	1.3697	39.14	23	1.1626	18.75
47	1.3612	38.32	22	1.1549	17.94
46	1.3530	37.51	21	1.1480	17.12
45	1.3440	36.69	20	1.1410	16.31
44	1.3345	35.88	19	1.1330	15.49
43	1.3255	35.06	18	1.1246	14.68
42	1.3165	34.25	17	1.1165	13.86
41	1.3080	33.43	16	1.1090	13.05
40	1.2999	32.61	15	1.1019	12.23
39	1.2913	31.80	14	1.0953	10.41
38	1.2826	30.98	13	1.0887	11.60
37	1.2740	30.17	12	1.0809	9.78
36	1.2654	29.35	11	1.0743	8.97
35	1.2572	28.54	10	1.0682	8.15
34	1.2490	27.72	9	1.0614	7.34
33	1.2409	26.91	8	1.0544	6.52
32	1.2334	26.09	7	1.0477	5.71
31	1.2260	25.28	6	1.0405	4.89
30	1.2184	24.46	5	1.0336	4.08
29	1.2108	23.65	4	1.0268	3.26
28	1.2032	22.83	3	1.0206	2.446
27	1.1956	22.01	2	1.0140	1.63
26	1.1876	21.20	1	1.0074	0.8154

5. A more easy, and at the same time more accurate method of determining the strength or value of sulphuric acid, is by ascertaining its saturating power; and the most convenient way of doing this is, perhaps, by water of ammonia of a standard strength, as was first proposed, I believe, by Dr. Ure. For this purpose, a given weight of the acid should be diluted with water, and water of ammonia of specific gravity 0.992 is poured from an alkalimeter into it, until complete saturation is obtained. Every 1000 grains-measure of such ammonia contains one equivalent, or 17 grains of ammonia, and saturates, therefore, exactly one equivalent, or 40 grains of dry sulphuric acid, or 49 grains of monohydrated sulphuric acid.

6. Instead of ammonia-water, carbonate of soda may be used as a test of the saturating power or actual value of the acid. For this purpose a known weight of dry, neutral carbonate of soda, prepared as described in the article on *Alkalimetry*, should be dissolved in water, and the solution is then gradually added to the acid until complete saturation is obtained, exactly as in alkalimetry; that is to say, by dissolving the carbonate of soda in such quantity, that each 1000 grains-measure contain 54 grains of carbonate of soda, which therefore represent 40 grains of anhydrous sulphuric acid.

7. Let us suppose, for example, that 54 grains of dry, neutral carbonate of soda having been dissolved in 1000 grains-measure of water, 85 alkalimetrical divisions (850 grains-measure) have been required to saturate 100 grains of the acid under examination previously diluted with water, if need be; then by a simple rule of proportion, we say, if 100 divisions (1000 grains-measure) containing 54 grains of carbonate of soda, saturate 40 of anhydrous, or dry sulphuric acid, 85 divisions (850 grains-measure) have, therefore, saturated 34 grains of the same acid; and therefore the acid under examination contains 34 per cent. of real or anhydrous acid.

$$100 : 40 :: 85 : x = 34.$$

8. But let us suppose that 100 grains of the acid under examination, previously diluted with water, have required 160 divisions (1600 grains-measure) of the carbonate of soda test-solution; then we say, if 100 divisions of the test carbonate of soda represent 40 gr. of dry acid, 160 divisions represent 64 per cent. of dry acid.

9. If the sulphuric acid under examination contains no sulphates in solution, its strength may be ascertained by means of a test-solution of chloride of barium; for this purpose 1050 gr. of chloride of barium should be dissolved in 10,000 grains-measure of pure water, and poured gradually into a given quantity of sulphuric acid until it ceases to pro-

duce a precipitate. Each 1000 grains-measure of the chloride of barium test-liquor corresponds to 117 grains of sulphate of baryta, or to 40 grains of sulphuric acid. Towards the end a more dilute test-liquor may be employed.

10. The sulphuric acid of commerce always contains *sulphate of lead*, and occasionally *tin*, *nitric acid*, and *arsenic*. It is very often adulterated with *sulphate of potash*, $2\frac{1}{2}$ per cent. of which are sufficient to increase the gravity of the concentrated acid to 1.860. But whether sulphuric acid has been sophisticated or not, may at once be detected simply by evaporating a given weight of the sample in a platinum capsule. The dry residuum should not exceed one per cent.

11. When sulphuric acid contains *sulphate of lead*, it becomes turbid by dilution with water; because sulphate of lead, though soluble in the concentrated acid, is insoluble in that which is diluted, and may be at once removed by filtering. The presence of sulphate of lead may likewise be detected by passing a stream of sulphuretted hydrogen through it; for, in that case, it becomes blackish or brown.

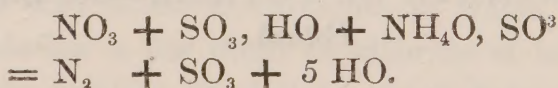
12. The presence of *arsenic*, or of *arsenious acid*, is detected also by a stream of sulphuretted hydrogen, which, in that case, will produce a yellow precipitate soluble in hydrosulphuret of ammonia. According to M. Dupasquier, when sulphuric acid contains arsenic, it may be purified by treatment with sulphuret of barium, which produces sulphate of baryta and sulphuret of arsenic, both of which are insoluble in the acid.

13. The presence of *tin* is detected also by sulphuretted hydrogen, which, in that case, produces a brown precipitate.

14. The presence of *nitric acid* is detected by pouring into the acid, without diluting it, a solution of protosulphate of iron, which will then produce a brown, or blackish-brown colour, which however disappears after some time; or, by adding a few drops of solution of indigo, and boiling the

whole, in which case the blue colour will be destroyed; or, by immersing copper trimmings into it, which will produce a disengagement of ruddy fumes; or, by adding a small portion of narcotine, which will then produce an intensely red colour.

15. The presence of nitrous compounds in sulphuric acid is sometimes extremely objectionable; for when such an acid is employed for the purpose of dissolving indigo, or of charring madder, a considerable quantity of the colouring matter may be irretrievably destroyed and lost. Nitrous compounds can exist in sulphuric acid only when the latter has not been brought to the proper degree of concentration, though nitric acid is sometimes added for decolorizing sulphuric acid which has been tinged by organic impurities. For the purpose of eliminating the nitrous compounds which may contaminate sulphuric acid, Pelouze recommends to heat the acid with a small quantity of sulphate of ammonia, the result being a formation of water and of nitrogen, as shown by the following equation:—



Nitrous acid (NO_3) plus monohydrated sulphuric acid ($\text{SO}_3 \text{HO}$), heated with sulphate of ammonia ($\text{NH}_4 \text{O}, \text{SO}_3$), gives two equivalents of nitrogen (N_2), plus sulphuric acid with five equivalents of water ($\text{SO}_3 + 5 \text{HO}$).

SULPHURIC ACID OF NORDHAUSEN.

FUMING SULPHURIC ACID. FUMING OIL OF VITRIOL.

1. The sulphuric acid of Nordhausen may be considered either as a solution of anhydrous sulphuric acid (SO_3) in the monohydrated, or ordinary sulphuric acid ($\text{SO}_3 \text{HO}$), or as a combination of two equivalents of anhydrous sulphuric acid

with one equivalent of water ($2 \text{ SO}_3 + \text{HO}$). It is an oily liquid, ordinarily of a brown colour, of specific gravity 1.9. The brownish colour is due to the presence of organic matter which has been charred by the acid. The anhydrous sulphuric acid which the fuming acid holds in solution is very volatile, and the fuming property of the acid is due to the volatilization of the anhydrous acid which always escapes at the ordinary temperature from its solution, and which, combining with the moisture of the atmosphere, is condensed in the form of fumes. The sulphuric acid of Nordhausen dissolves indigo much more readily than ordinary sulphuric acid; and, moreover, as it never contains any nitric acid, which destroys indigo, it is often employed in preference for that purpose. The sulphuric acid of Nordhausen always contains sulphurous acid, earthy matter, and also selenium; the mode of testing the purity or strength of the fuming acid is the same as we have described for the ordinary acid.

SUPERTARTRATE OF POTASH.—See *Bitartrate of Potash*.

SWEETMEATS.—See *Blanc Mange*.

TARTAR.—See *Cream of Tartar*.

TARTAR EMETIC.—See *Tartrate of Antimony and Potash*.

TARTARIC ACID.

1. Tartaric acid is not altered by exposure, it intumesces when heated, and then undergoes decomposition. It is

soluble in water and alcohol, but its aqueous solution soon turns mouldy.

2. Tartaric acid is often contaminated by lime; when this is the case, it fails in dissolving completely in alcohol, which it would do if pure. The presence of lime can be identified by dissolving a portion of the acid in water, neutralizing with ammonia, and then adding oxalate of ammonia, which will produce a precipitate of oxalate of lime, which, if in sufficient quantity, may be collected on a filter, washed, dried, moderately ignited until all the carbon is burnt; the residuum is carbonate of lime, which may then be weighed. 50 grains of carbonate of lime represent 28 of lime, or each grain of carbonate of lime contains 0.56292 grain of lime.

3. As tartaric acid is prepared by decomposing the super-tartrate of potash by carbonate of lime, so as to obtain a tartrate of lime, which is subsequently decomposed by sulphuric acid, the tartaric acid of commerce generally, or at least very often, retains a small quantity of sulphuric acid, the presence of which is detected by dissolving a portion of the tartaric acid under examination in water, and pouring into the solution a few drops of chloride of barium, which will produce a white precipitate of sulphate of baryta, if sulphuric acid be present, in which case chloride of barium should be added as long as it produces a precipitate, which may then be collected on a filter, washed, dried, and weighed. 117 grains of sulphate of baryta represent 40 grains of sulphuric acid, or each grain of sulphate of baryta obtained is equivalent to 0.34372 grain of sulphuric acid.

4. Tartaric acid is often adulterated with bitartrate of potash (cream of tartar); this fraud is easily detected by the residuum of carbonate of potash which is left after ignition in a platinum crucible.

TARTRATE OF ANTIMONY AND POTASH.

TARTAR EMETIC.

1. Tartar emetic crystallizes in octahedra or in tetrahedra, which are semi-transparent, colourless, slightly efflorescent, inodorous, and of a nauseous styptic taste. Exposed to heat, it blackens, is decomposed, and leaves a residuum of metallic antimony. It is soluble in fifteen parts of cold and in two parts of boiling water, but the solution is slow, especially when it is in crystals, or recently pulverized; it powerfully reddens litmus paper.

2. Tartar emetic is often contaminated by bitartrate of potash (cream of tartar); the presence of this impurity may be detected by mixing together eight parts of neutral acetate of lead, fifteen parts of acetic acid, specific gravity 1.064, and thirty-two parts of water. The solution thus obtained produces a precipitate when poured in solutions of cream of tartar, but none in those of tartar emetic. Mr. Henry says that $\frac{1}{200}$ th part of cream of tartar may thus be detected in tartar emetic. The precipitate requires some time to be produced.

3. Oxalate of ammonia may also be employed to test the purity of tartar emetic, the solution of which, if pure, is not precipitated by that salt.

TEA.

1. R. Warrington Esq., published in one of the numbers of the *Chemical Gazette*, in 1844, a paper entitled, "Observations on the Green Teas of Commerce," from which the following passage is extracted. "On submitting a sample of green tea supposed to be spurious, and which had been seized by the excise, to microscopic investigation, the author found that the variation of tints which had led him to this mode of

examination was dependent on adventitious substances, mechanically attached or dusted on the surface of the curled leaves. The principal part of this powder was of a white colour, interspersed with particles of an orange, and of a bright blue. From the abraded dust of this sample, obtained by agitation, some of the latter were separated, and proved on examination to be Prussian blue; the orange portion was probably some vegetable colour, and the white and principal part was found to contain silica, alumina, a little lime, and magnesia, and was probably kaolin or powdered agalmatolite, more particularly from the rubbed and prominent parts of the tea assuming a polished appearance. A great variety of other samples of teas were submitted to examination, but in all cases they were found to be faced with various substances, to give them the bloom and colour which is so distinct a characteristic of the green teas of commerce. The unglazed varieties appear to have had no blueing material applied. Very high qualities of glazed teas have this facing apparently tinted of a uniform pale blue before application, whilst others, still of high quality, and embracing the great part of the samples examined, have both the white and the blue particles very distinct, the latter varying in its quantity, the low qualities, as Twankay, being pretty thickly powdered. When this facing was removed, the tea was found to be of a black colour, but without the corrugated aspect presented by black teas ordinarily, and which evidently arises from the higher temperature to which they are subjected during the process of curing and drying. The substances separated from these green teas were sulphate of lime, a material analogous to kaolin and Prussian blue, together with some yellow colouring body. It is evident that the whole of these teas come to this country in a dressed or adulterated state, a conclusion which is satisfactorily confirmed by the opinions and observations of individuals long resident in China."

2. From this statement it would appear that the substances which were found by Mr. Warrington in the above men-

tioned teas were *Prussian blue*, an orange matter, probably of vegetable origin, (but which in other cases has turned out to be *chromate of lead*), *silica* or *sand*, *alumina* or *clay*, *lime*, *sulphate of lime*, and *magnesia*.

3. It may be that the sophistications alluded to in Mr. Warrington's paper were of Chinese origin, but unfortunately this species of fraud is not confined to that far distant region ; *it is a positive fact* that the bloom is most extensively given to green teas *at home*, in *the warehouses of our own merchants*, by means of magnesia and Prussian blue. It should be known that the seemingly unbroken appearance of the sheet of metal, in which the tea is tightly packed in the chest, is no criterion of its genuineness. Through the hole which is made in the metallic sheet for the purpose of taking sample, the whole of its contents are emptied on a clean floor, and the tea is then mixed with whatever composition it may be thought fit to add, or *worked up* with teas of an inferior quality, or which by themselves would be unsaleable. The repacking is done by reintroducing the tea by small portions at a time, and the workman from time to time carefully puts his foot through the opening which was made for taking sample, and through which the tea was emptied, then grasping a rope fixed against the wall, in order to steady himself and keep his balance without danger of enlarging the hole, he heavily treads the tea down by a series of jerks, until at last a quantity of tea equal to the weight at first emptied is thus pressed into the same bulk or space as before, so that the chest has all the appearance of a genuine importation. Even this trouble of repacking the sophisticated tea is grumbled at by the tea-dealer or merchant, and many attempts have been made to imitate the beautiful seam or soldering by which the sheets of metal are united, which, of course, would enable the sophisticator to repack his teas *after treatment* at once and *off hand*, but the Chinese mode has hitherto baffled the ingenuity of all the tin-smiths and plumbers who have been applied to. The sheet-lead of the package may be easily

enough taken asunder, but the re-soldering is another affair, and could not hitherto be even remotely approached.

4. Besides the substances which have been named before, black tea is also mixed sometimes with pulverized extract of logwood ; this is immediately detected by moistening a small portion of the tea-leaves of the sample with water, and rubbing it gently about upon a sheet of white paper, which, in that case, will be stained bluish-black ; moreover, if a portion of the tea, being thrown in cold water, imparts immediately to the liquid a pinkish or purplish colour, which is rendered red by the addition of a few drops of sulphuric acid, it is a sign of the presence of logwood ; for genuine black tea produces only, after a time, a golden brown liquor which is not reddened by sulphuric acid. This addition of logwood to black tea is for the purpose of simulating strength by the high colour of the infusion, something like the addition of chicory to coffee. I have met with this kind of adulteration in teas represented as souchong and pekoe.

5. The other fixed impurities may be determined as follows : Take 500 grains of the tea under examination, especially the powder which results from abrasion, and incinerate them by small portions at a time in a counterpoised platinum crucible. The ashes, after perfect ignition, should not exceed 27 grains ; if in more considerable quantity, the addition of fixed substances may be suspected. If metallic salts, and especially those of lead are suspected to be present, a porcelain crucible should be used, for a platinum one would be damaged.

6. If the tea-leaves have been dusted with *chromate of lead*, the above quantity of tea should be calcined with nitrate of potash, which will leave a greenish residuum, partly soluble in distilled water. The undissolved portion is then treated by hot acetic acid, and evaporated to dryness ; the dry residuum is then redissolved in water, and the solution being treated by a current of sulphuretted hydrogen will yield a black precipitate of sulphuret of lead.* This black

* See the Apparatus, page 2, § 5.

precipitate being digested in hot nitric acid, will dissolve therein, and the concentrated solution, tested by iodide of potassium, will yield the characteristic yellow precipitate of iodide of lead.

7. If tea has been coloured by a *salt of copper*, it may be immediately detected by putting a pinch of the tea into a flask with a small quantity of cold water, agitating or shaking it for some time, and throwing the whole upon a filter; a portion of the liquor which filters through being tested with ammonia, will immediately assume a beautiful sapphire-blue colour; another portion of the filtrate being tested with ferrocyanide of potassium, will produce a reddish-brown precipitate of ferrocyanide of copper. These re-actions require sometimes a few hours to be manifested, the quantity of the salt of copper, when present, being always exceedingly small. A bar of metallic iron left for some hours in the filtrate, slightly acidified, will receive a metallic coating of copper, if a salt of this metal is present. Or the ashes of the incinerated portion of which we spoke before, may be treated by a small quantity of nitric acid, and evaporated to dryness. The dry mass is then digested in water and thrown on a small filter. The filtrate may now be treated by ferrocyanuret of potassium, or by ammonia, and hydrosulphuret of ammonia. I think, however, that the addition of salts of copper to tea is rare; at any rate, I never could detect the presence of copper in the various samples in which I looked for that metal.

8. After having shaken a certain quantity of tea in a flask with water, the heavy impurities, such as *silica*, *sulphate of lime*, *lime*, *magnesia*, will settle at the bottom; the supernatant leaves may be carefully removed by means of a cullender or perforated spoon, and the sediment may then be separated by carefully decanting the water. This sediment should be incinerated, and treated by a small quantity of hydrochloric acid, which will leave the silica and sulphate of lime in an insoluble state. These are separated by filtering,

and the filtrate which contains the lime and the magnesia is treated by sulphuric acid and alcohol, which will produce a white precipitate if lime is present. This precipitate, which is sulphate of lime, is collected on a filter, and if the filtrate, being tested by ammonia-phosphate of soda, produces a white precipitate, it is a sign of the presence of magnesia.

9. The insoluble portion which was incinerated, and which refused to dissolve in hydrochloric acid, may be boiled in about 500 times its weight of water and filtered; if the filtrate, being tested with solution of chloride of barium, produces a white precipitate of sulphate of baryta, sulphate of lime was present. The residuum which remains altogether insoluble is silica, which may be easily recognised by its grittiness.

10. Black tea is sometimes dusted with a little plumbago (black lead), which gives it a shining or lustrous appearance. This impurity remains as a black powder with the silica.

11. Tea is sometimes adulterated by an admixture of sloe, or elder leaves; the only means of detecting this fraud is by a careful examination of the leaves after they have been untwisted by infusion or moisture; tea-leaves have a different structure, they are more elongated, the edges are more deeply serrated and more delicate than those of the above-named plants.

12. Lastly, tea is sometimes adulterated, it is said, by an admixture of tea-leaves which have been already used, and which are dried again and twisted in imitation of the state in which they were originally. This kind of fraud can hardly be detected in any other way than by the want of flavour of the infusion which such tea yields.

13. A few months ago, a brownish powder was, and I believe continues to be, offered for sale under the name of *la veno beno*, one quarter of a spoonful of which is described as having the wonderful property of giving to two tea-spoonfuls of tea, the strength of four, with an *improved flavour*, besides producing a saving of 75 per cent. !

14. *La veno beno* has been represented as being the leaf of a tree, and that tree a climbing plant, well known in the east under the name of *Paun*, which is clearly a much less pretty, and, consequently, a much less *saleable* name than *veno beno*.

15. But by whatever name called, *la veno beno* is neither plant nor leaf, but simply a mixture of a very small portion of tea-powder (broken tea-leaves), with an excessively large quantity (upwards of 90 per cent.) of pulverized catechu. Catechu, or terra japonica, is an astringent extract, which is extensively used by tanners and dyers as a substitute for gall-nuts. The extraordinary properties of *veno beno* lie therefore altogether in the contrivance by which a price five or six times greater than its real value, is extracted from the pockets of a *well-advertised* public. In my opinion it has another property, though not an extraordinary one, I mean that of spoiling the flavour of good tea, the fine aroma of which, far from being *improved* by the recommended addition, is, on the contrary, overcome and destroyed by the sweetish-astringent, and peculiar flavour of the catechu. To me, therefore, the addition would prove a clear loss, for, having tried it, I could not drink the infusion, which was thus rendered more rough to the tongue, but singularly vapid and flat, yet the quantity used was below that prescribed. *La veno beno* acts, therefore, upon tea somewhat in the same way as chicory does upon coffee; with this important difference, however, that coffee adulterated, or mixed with chicory, still retains a taste of coffee and is drinkable, even though thus adulterated to a considerable extent; but the aroma of tea being much more delicate and fugitive, any substance having a peculiar taste is sure to predominate, if employed to any notable extent.

16. We should, however, be grateful, to a certain extent, to the *inventor* for selling his *veno beno* candidly, though under catching terms, as a tea-adulterating substance, which may or may not be purchased; and we must hope that it will

not come into either general or partial use in the grocer's shop, ready mixed with the tea that he retails, as is done with chicory and coffee; though, I am sorry to say, a sample of tea sold by a grocer has already come into my hands which was undoubtedly sprinkled with *veno beno* or *catechu*.

TERRA JAPONICA.—See *Catechu*.

T I N.

1. Metallic tin is solid, malleable, of a white colour very much resembling that of silver, but with a slight tint of yellow, and is not sensibly altered by exposure to the air; it emits a peculiar crackling noise when bent, the intensity of which, however, is considerably diminished when alloyed with other metals. It exhales a peculiar metallic odour when rubbed, and melts at 442° Fahr.; its specific gravity varies from 7.29 to 7.6, and is not augmented by hammering. The best kind of tin is known in commerce under the name of *grain-tin*; that called *block-tin* is less pure. Tin is not volatilizable by heat. It is insoluble in nitric acid, by which, however, it is converted into peroxyde of tin, but it is readily dissolved by hydrochloric acid.

2. Commercial tin is often contaminated by several metals with which it is accidentally or purposely mixed, but which render it unfit for various purposes; hence the importance of ascertaining whether it is pure or impure. According to Vauquelin, when tin has a bluish or greyish tinge, it is a sign of the presence of *copper*, *lead*, *iron*, or *antimony*.

3. The best way of ascertaining the purity of tin is by taking, for example, about 1,000 grains of the tin under examination, melting them in an iron-ladle, and when melted, pouring it carefully either into another large iron-ladle, or in a porcelain-capsule, tilting it gently on one side before the metal has cooled, in order to

obtain a bright and perfectly smooth surface, free from oxyde or impurity. If the convex surface of the metal is of a perfectly white colour, free from spots or wrinkles, it is a sign of purity; but in the contrary case, or if it has a bluish, or greyish, or leaden tinge, presenting a sort of *moiré métallique*, then the above metals may be present.

4. If, however, by comparing the melted piece with another sample of tin known to be pure, it is harder and whiter than it should be, the presence of arsenic is probable. Arsenic considerably hardens tin.

5. Pure tin when bent produces one single and strong crackling noise; but if impure, the crackling noise is feeble, and gives the idea of a tearing noise, more prolonged than when the metal is pure. When this takes place, the presence of lead or of copper may be inferred.

6. If a piece of tin, being bent several times backward and forwards, first becomes elongated before it breaks; and if the fracture is in points, and has a dead-white colour and looks soft, the tin is pure. When *lead*, *copper*, or *iron* are present, the tin is more brittle, and the fracture is granular and grey.

7. But one of the best and easiest methods is simply to melt and cast a portion of the metal into a flat disc, as we said before. If the metal is pure, the surface of the disc is highly polished and perfectly white.

8. The specific gravity of the tin is also a sign of its purity; for, as pure tin is lighter than the metals with which it may be alloyed, its specific gravity will, of course, be so much the greater in proportion to the quantity of the alloy.

9. The nature of the foreign metals by which tin is contaminated, may be detected by dissolving a portion of the sample in dilute hydrochloric acid. If brown flakes (or a black powder) are deposited, they are owing to the presence of arsenic.

10. If a portion of the tin, being dissolved in aqua regia, and the solution filtered and diluted with water, produces a

blue precipitate (prussian blue), when tested with solution of ferrocyanuret of potassium, *iron* is present.

11. If the precipitate produced by that re-agent is purple, *copper* and *iron* are present; in which case a bar of iron plunged in the nitric acid solution of the tin, will receive a coating of copper, if that metal be present.

12. If a solution of sulphate of soda produces a white precipitate, *lead* is present.

13. The amount of these impurities may be determined as follows :—

14. Take about 1,000 grains of the sample, first reduced into small bits or granulated (which is easily done by melting the tin and triturating it in a mortar whilst cooling), and dissolve them in about a pint of dilute hydrochloric acid; the addition of a few drops of dilute nitric acid, from time to time, accelerates the solution of the tin. If the metal contains arsenic, a residuum, insoluble in hydrochloric acid, will be left, which is arsenic almost in a pure state, and which may be recognized as such by the aliaceous odour which it evolves when thrown upon ignited coals. It is necessary to employ only a dilute acid in order that the metal may dissolve slowly, for otherwise no arsenic would be deposited, for it would be converted into arsenuretted hydrogen, which, however, may be recognized as such by Marsh's apparatus.

15. The quantity of *lead*, of *copper*, or of *iron*, may be estimated by treating one hundred grains of the sample with boiling nitric acid, which will dissolve these metals, and leave the tin in the state of peroxyde of tin (metastannic acid $\text{Sn}_5 \text{O}_{10} 10 \text{HO}$, or after being exposed for some time to a temperature of 212 Fahr. $\text{Sn}_5 \text{O}_{10} 5 \text{HO}$). The best way is to evaporate the nitric acid solution with the undissolved peroxyde of tin, until the excess of nitric acid is mostly volatilized, water is then added, the peroxyde of tin is collected on a filter, washed, ignited, and weighed; each grain of peroxyde of tin thus obtained contains 0.78616 of

tin. The loss, or difference, indicates, of course, the other metals with which the tin was alloyed.

16. If the operator now wishes to ascertain the respective proportion of these foreign metals, he should proceed as follows :—

17. The liquor which was filtered from the peroxyde of tin should be treated by dilute sulphuric acid, or by a solution of sulphate of soda ; if this produces a white precipitate, it is sulphate of lead ; this precipitate should be collected on a filter, washed, and then ignited in a crucible and weighed ; 100 grains of sulphate of lead contain 73.68 of oxyde of lead, and, consequently, 68.41 of metallic lead ; or each grain of sulphate of lead contains 0.68287 of lead.

18. After having eliminated the lead in the state of sulphate of lead, as we just said, and if only *iron* is present, it may be determined as peroxyde of iron by means of caustic ammonia ; but if copper be present at the same time, ammonia is hardly the proper re-agent for separating these two metals from each other, because, although protoxyde of copper is very soluble in ammonia, yet the iron precipitated by that re-agent in such a case always retains a somewhat considerable quantity of oxyde of copper, which cannot be eliminated or redissolved by any excess of ammonia. It is therefore better (provided no other oxydes which can be precipitated by sulphuretted hydrogen from an acid solution are present) to pass a stream of that gas slowly through the filtered acid liquor until it smells strongly of the gas.* The black precipitate produced is sulphuret of copper, and must be rapidly collected on a filter, and washed without interruption with water containing a little sulphuretted hydrogen. After washing the precipitated sulphuret of copper, it should be dried, separated from the filter as cleanly as possible, and put into a flask. The filter, which retains a little sulphuret of copper, must now be burnt upon the cover of a crucible,

* See the Apparatus, page 2, § 5.

and the ashes are added to the sulphuret in the flask. Nitric acid, or aqua regia, is then poured upon the whole, which is left to digest therein until the sulphur liberated has acquired a pure yellow colour. The sulphur is separated by filtering, and the copper is precipitated by pouring a solution of potash into the filtered liquor as long as a precipitate is produced. The whole is then boiled; the peroxyde of copper thus produced is collected on a filter, washed with hot water, ignited with the filter in a platinum crucible, and weighed as soon as cold in the crucible, which should be kept carefully covered, as, otherwise, the protoxyde of copper would absorb moisture which would thus increase the weight. Each grain of protoxyde of copper contains 0.79826 of copper.

19. Tin may be obtained in the pure state by dissolving commercial tin in hydrochloric acid, so as to obtain a concentrated solution, and when the solution has cooled, water is to be carefully poured upon it, so that the water may form a distinct layer above the tin solution. A blade of tin is then plunged through the liquor down to the bottom, and in the course of a few hours the blade becomes covered with exceedingly fine crystals of tin. This re-action is due to the slight electric current produced by the immersion of the tin through the two layers of chloride and of water, which current is sufficient to determine the precipitation of the tin.

20. The quantity of arsenic which is contained in ordinary tin does not amount generally to more than $\frac{1}{800}$ th part, and the tin of Malacca and of Banca do not contain appreciable quantities of this poisonous metal.

21. Pewterers generally alloy their tin with a little antimony in order to render the metal harder; the analysis of such an alloy may be made as described in the article on *Antimony*, to which the reader is referred.

22. The *native oxyde of tin*, or *pyramidal tin-ore*, is the principal ore of tin; it consists of peroxyde of tin mixed with small quantities of iron and of manganese; it is so

dense that it is insoluble in acids, and it resembles, in that case, the artificial peroxyde of tin after ignition.

23. In order to determine the quantity of foreign substances contained in the ore, it (the ore) should be finely pulverized, levigated, mixed with three or four times its weight of carbonate of potash or of soda, and fused. After fusion, the peroxyde of tin may be dissolved in hydrochloric acid, and the solution being evaporated, in order to expel the excess of acid, is then diluted with a sufficient quantity of water and filtered; sulphuretted hydrogen is passed through the liquor until it smells strongly of the gas, which will precipitate the tin in the state of sulphuret of tin.* The precipitated sulphuret of tin is then somewhat dried, put into an open platinum-crucible, and gradually roasted therein, until it ceases to evolve any odour of sulphurous acid (burning sulphur), the heat may then be increased to a good red. That which remains in the crucible is peroxyde of tin, which should be white, it is then weighed. A small piece of carbonate of ammonia should be placed upon the peroxyde of tin in the platinum-crucible, and the whole again strongly ignited. This must be repeated as long as a loss of weight is observed. The carbonate of ammonia is employed for the purpose of expelling the last traces of sulphuric acid, produced by the roasting, which the peroxyde of tin might retain.

24. If the operator wishes to isolate the iron, and to determine its quantity, the filtered liquor should be heated until all odour of sulphuretted hydrogen has vanished; some nitric acid is then added, and the liquor is boiled, in order to peroxydize the iron, which may then be precipitated by ammonia, collected on a filter, washed, dried, ignited, and weighed. Each grain of peroxyde of iron contains 0.69338 grain of metallic iron.

TINKAL.—See *Borax*.

* See the Apparatus, page 2, § 5.

TOMBAC.—See *German Silver*.

TURNBULL'S BLUE.—See *Prussian Blue*.

TUTENAG.—See *German Silver*.

VERDEGRIS.—See *Acetate of Copper*.

VERDITER.—See *Acetate of Copper*.

VERMILION.

CINNABAR. SULPHURET OF MERCURY.

1. Cinnabar and vermilion are the same substance, that is, a combination of sulphur and of mercury. Cinnabar is in lumps or amorphous masses of variable size, of a reddish-purple colour, and consisting of an agglomeration of needles, parallel to each other. The specific gravity of cinnabar is 10.218. When cinnabar is pulverized it forms the beautiful red pigment called vermilion.

2. Vermilion is often fraudulently mixed with *red lead*, *peroxyde of iron*, *brick-dust*, and with *sulphuret of arsenic*.

3. The presence of *red lead*, *peroxyde of iron*, and of *brick-dust* is easily detected, because vermilion being volatilizable by heat, it is sufficient to pour a small portion of the vermilion under examination into a well-scoured iron-spoon, and to heat it; the vermilion soon evaporates, whilst the red lead, brick-dust, and peroxyde of iron, not being volatile, are left behind. The difference of weight, before and after the experiment, indicates at once the amount of fraud.

4. If *sulphuret of arsenic* is present, it may be detected by throwing a little of the vermilion under examination upon

ignited charcoal, when the characteristic odour of garlic, indicating arsenic, becomes perceptible. The odour of garlic is developed better, by mixing a little of the vermilion with carbonate of soda, and heating the mixture before a blow-pipe upon charcoal. The presence of sulphuret of arsenic may also be detected by boiling a portion of the vermilion in caustic potash and filtering, supersaturating the filtrate with nitric acid, and then passing a slow current of sulphuretted hydrogen through the solution, which will precipitate the arsenic in the state of yellow sulphuret of arsenic.

5. After having ascertained the presence of arsenic, as above said, its quantity may be determined in the following manner :— Take a given weight of the vermilion in very fine powder, put it into a flask, and treat it therein with aqua-regia until the sulphur, which separates, has agglomerated into yellow lumps, of a perfect yellow colour ; fresh portions of aqua regia being added from time to time in order to insure complete decomposition. The solution is filtered and supersaturated with ammonia ; an excess of hydrosulphuret of ammonia is then added, the flask is loosely corked up, and the whole is left to digest in a warm place for ten or twelve hours. The flask is allowed to cool, and when quite cold, the insoluble sulphuret of mercury may be separated by filtering. The filtrate, which contains the sulphuret of arsenic, should be diluted with a large quantity of water, acidified with a little hydrochloric or acetic acid, until it is slightly acid, and the whole is left to digest at a gentle heat, until all odour of sulphuretted hydrogen has disappeared. The sulphuret of arsenic which was held in solution will then have completely precipitated, it should therefore be collected on a counterpoised filter and weighed. It is necessary, however, for accurate purposes, to analyse the sulphuret of arsenic thus obtained, because it is mixed with sulphur, from the decomposition of the hydrosulphuret of ammonia by the acid employed.

6. The presence of *red led* may be identified by boiling a portion of the vermilion in acetic acid, which will dissolve the lead, and if on passing a current of sulphuretted hydrogen through a portion of the filtered solution, a black precipitate of sulphuret of lead is obtained, or if, in testing another portion of the filtered solution with iodide of potassium, a yellow precipitate is obtained, it is a sign of the presence of lead.

7. In order to determine the quantity of the red lead, the black precipitate of sulphuret of lead produced in the acetic acid-solution, as above mentioned, is treated with the filter by hydrochloric acid, which produces a disengagement of sulphuretted hydrogen. Nitric acid is then added, and the whole is evaporated to dryness ; sulphuric acid is now poured with care on the dry mass, the excess of sulphuric acid is eliminated by heat, and the remaining sulphate of lead is weighed. 152 grains of sulphate of lead = 104 of lead, or 344 grains of red lead.

V I N E G A R.

ACETIC ACID. PYROLIGNOUS ACID.

1. Vinegar is the name given to dilute acetic acid, the strength, flavour, and composition of which varies according to the sources from which it has been produced. The best vinegar is that which is obtained from wine, by exposing it to the action of the air, at a proper temperature. In this country vinegar is made from beer, or from a *wort* prepared for the purpose, but cider, perry, and a great number of alcholic or saccharine liquors can be converted into vinegar. 124 parts of sugar, 80 parts of yeast, and 868 parts of water, exposed to the air for about a month, yield vinegar of a good quality. Vinegar is extensively manufactured also from the destructive distillation of wood, and is known under the name of pyrolignous acid.

2. Pure acetic acid is solid up to a temperature of $62^{\circ}.6$ Fahr. At that temperature it melts into a colourless liquid of specific gravity 1.063 ; it has a peculiar characteristic odour, and is as corrosive as the most powerful mineral acids. Acetic acid is soluble in water in all proportions ; it boils at 248° Fahr. ; its vapour is inflammable, and burns with a blue flame. The density of acetic acid is augmented by diluting it with water. Acetic acid, which contains only one equivalent of water, has a density of 1.063 ; by diluting it with about 30 per cent. of water, its density becomes 1.079, which is its maximum gravity ; if diluted with more water, its specific gravity is the same as when it contains only one equivalent of water, as shown in the following table by M. Mollerat :

Specific Gravity.	Quantity of Water per cent. of Concentrated Acid.
1.0630	0.0
1.0742	10.0
1.0770	22.5
1.0791	32.5
1.0763	43.0
1.0742	55.0
1.0728	66.5
1.0558	97.5
1.0637	108.5
1.0630	112.2

3. This table shows that the strength of acetic acid cannot be estimated from its specific gravity.

4. Vinegar is often adulterated in various ways, namely, by dilution with water, or with vinegar of inferior quality, or by an addition of pyrolignous acid, or of stronger mineral acids, such as sulphuric, hydrochloric, and nitric acids. Its pungency is often increased by maceration with acrid substances, such as chillies or cayenne-pepper, long pepper, mustard-seed, &c. ; it is also mixed sometimes with metallic salts, common salt, &c.

5. We have shown before that the density of the acid cannot serve to indicate its strength. The only accurate method of determining the quantity of acid contained in vinegar, is by ascertaining the quantity of dry carbonate of soda or of potash which may be required to saturate it. For this purpose dry carbonate of soda is preferable to carbonate of potash, because the latter absorbs rapidly the moisture of the air which produces an increase, and of course gives an erroneous result.

6. Professor Soubeiran says that 100 parts of vinegar of good quality (French vinegar, vinaigre d'Orléans), are saturated by 10 parts of dry carbonate of potash.

7. But whether carbonate of potash or of soda are employed, it is much better to use them in solution of a known strength forming a test-liquor. Such a test-liquor may be made by dissolving 540 grains of dry carbonate of soda in 10,000 grains-measure of water. 1,000 grains-measure (100 alkalimetric divisions) of such a liquor are then taken and poured gradually from an alkalimeter-tube into a given measure (one fluid ounce for example) of the vinegar under examination, until its acid is saturated. 100 divisions (1,000 grains-measure) of such a test-liquor, saturate exactly 51 grs. of pure anhydrous acetic acid—one ounce of good vinegar should require from 58 to 60 divisions (580 to 600 grains-measure) for saturation. Before adding the test-solution of carbonate of soda, a small quantity of tincture of litmus should be added to the vinegar in order to guide the operator, and enable him to see when the point of saturation is nearly attained. Towards the end of the experiment heat should be applied in order to expel the carbonic acid. The operator will perceive that, as the saturation proceeds, the odour of vinegar disappears, and is replaced by a peculiar soapy odour; the red colour of the vinegar, tinged with litmus at the same time, is gradually changing into blue. The experiment is, in every respect, conducted as for alkalimetry.—(See *Alkalimetry*),

8. When the experiment is finished, the operator reads off the number of divisions employed, and if, for example, 58 divisions have been employed to saturate one fluid ounce of vinegar, then it contained 29.58 grains of pure anhydrous acetic acid.

9. The ammonia test-liquor, recommended by Dr. Ure, which admits also of very great accuracy, may be resorted to for the same purpose. The process, as we already said in the article on *Acidimetry*, to which the reader is referred, consists, first, in pouring some neutral tincture of litmus into the vinegar to be tested, so as to impart a feeble-red tinge to it, and then testing with the ammoniacal solution of sp. gr. 0.992 ; 1,000 grains-measure of such an ammoniacal solution, containing exactly one equivalent of ammonia, neutralize, consequently, one equivalent of acetic acid, that is, 51 grains of the anhydrous, or 60 of the monohydrated acid. The test ammonia can always be easily kept at the proper strength by two hydrostatic glass-beads, made, the one to float, the other to sink in the ammonia liquor of the proper gravity, as above said. If, then, a portion of such a test-liquor of ammonia be added to the slightly-reddened vinegar until the colour is neutralized, the number of grains-measure employed being multiplied by 51 or 60, will give a product which indicates the per centage of either real anhydrous or hydrated acid in the vinegar operated upon.

10. It is evident that, in the above acidimetical process, account must be taken of any mineral acid which may have been, and is generally added to vinegar, and the presence and amount of which must, of course, be determined.

Detection of Sulphuric Acid in Vinegar.

11. The presence of sulphuric acid may be easily detected, and its amount determined in vinegar, in various ways :—

12. 1st. If the quantity of sulphuric acid present in the vinegar exceeds two per cent., it may be detected by dipping a

clean quill in the vinegar, and writing with it upon a sheet of white paper. If the paper be now strongly warmed before the fire, the writing traced with the vinegar will become visible, because the paper will be charred by the sulphuric acid.

13. 2nd. If a portion of the vinegar being evaporated in a porcelain or platinum capsule, leaves a residuum which becomes charred and black, evolving, moreover, towards the end, that is, as the evaporation draws towards a close, thick, suffocating fumes, sulphuric acid is present, the fumes being due to its volatilization. When vinegar contains no sulphuric acid, the fumes evolved smell of vinegar only, and the evaporation leaves a brownish or brown extract, which does not become charred.

14. 3rd. The presence of sulphuric acid may also be detected as follows :—Dissolve one part of sugar in 30 parts of water, dip a small porcelain capsule into the solution, and expose it to a steam-heat ; if a drop of the vinegar containing sulphuric acid is dropped into the capsule, the sugar will be charred, and a spot of an intense black colour will be produced at the point where the vinegar was put. This effect takes place even when as little as one part of sulphuric acid is present in 300 parts of vinegar. If the proportion of sulphuric acid is less, a greenish spot will appear, even when as little as $\frac{1}{8000}$ th of sulphuric acid is present.

15. These methods offer, therefore, a ready and easy means of detecting the presence of free sulphuric acid ; but, in order to determine its quantity, another method must be resorted to, for which purpose a salt of barium, and, preferably, solution of chloride of barium is employed. Yet, it is necessary to bear in mind, that the barytic salts produce a precipitate, not only with free sulphuric acid, but likewise with the solutions of the sulphates. Now, on the one hand, genuine vinegar always contains, naturally, a small quantity of soluble sulphates ; but, moreover, the English vinegar, made from malt, always contains a certain proportion of sulphuric acid,

though the quantity which was legally allowed is often much exceeded. The quantity of sulphuric acid allowed is $\frac{1}{1000}$ of the weight of the vinegar.

16. The best way of determining the quantity of the sulphuric acid contained in vinegar, consists in taking a known quantity of the vinegar under examination, eight fluid ounces, for example, and evaporating it in a steam, or water-bath, to about one-eighth of its bulk, allowing the capsule to cool, and adding five or six times its bulk of alcohol, the whole being well stirred with a glass rod. The liquor should then be filtered, in order to separate the insoluble sulphates, and solution of chloride of barium being then added to the filtered liquor, a precipitate of sulphate of baryta will be produced, if sulphuric acid is present. The precipitated sulphate of baryta should be drenched with nitric acid, filtered, washed, dried, slightly ignited, and weighed. 117 gr. of sulphate of baryta represent 40 of anhydrous sulphuric acid; or, each grain of sulphate of baryta contains 0.34372 of sulphuric acid.

17. For less accurate purposes the operator may dispense with evaporating the vinegar, and treating it with alcohol, and may at once estimate the sulphuric acid, by pouring chloride of barium in a known quantity of the vinegar until a precipitate ceases to be produced. The precipitate is then treated as above said.

Detection and estimation of hydrochloric acid in vinegar.

18. The presence of hydrochloric acid in vinegar is generally detected by pouring immediately into it a solution of nitrate of silver, which, in that case, will form a white precipitate of chloride of silver insoluble in nitric acid. Considering, however, that vinegar naturally contains a small quantity of soluble chlorides, it is better to introduce about 10,000 grains-measure of the vinegar under examination into a tubulated retort, provided with a receiver, kept cool by a

wet towel, in order to condense the liquor which distils over. For this purpose a Liebig glass-tube condenser is much more handy. The portion of vinegar which distils over may now be tested with solution of nitrate of silver, which produces a white precipitate of chloride of silver, if the vinegar have been adulterated with hydrochloric acid. In that case the precipitated chloride of silver must be collected on a filter, washed with water, acidified with pure nitric acid, and then with distilled water, after which it is dried, carefully ignited, and weighed. 144 grains of chloride of silver correspond to 37 grains of hydrochloric acid, or each grain of chloride of silver contains 0.25366 of hydrochloric acid.

19. Before filtering the precipitated chloride of silver, it is advisable to heat moderately the liquor containing it, in order to agglomerate it well.

Detection of nitric acid in vinegar.

20. Vinegar is seldom adulterated by nitric acid. The presence of this acid, however, may be easily detected by saturating the vinegar with carbonate of potash, and evaporating to dryness, which will leave a crystalline mass, in which the presence of nitrate of potash may be detected by the deflagration which takes place when a portion of it is thrown upon ignited charcoal.

21. The crystalline mass obtained may also be mixed with bright copper turnings, and then treated by sulphuric acid, which will produce ruddy fumes, if nitric acid, or a nitrate be present.

22. Another method consists in putting a small quantity of the vinegar under examination into a small capsule, along with a few scrapings from a quill pen. On applying heat, if the pen scrapings turn yellow, it is a proof that the vinegar contains free nitric acid.

Detection of tartaric acid in vinegar.

23. Vinegar is sometimes adulterated by a solution of

tartaric acid. This addition may be detected, first, by evaporating a certain quantity of the vinegar to about one-fourth of its bulk, and pouring into the concentrated liquor, after filtering it, a solution of chloride of potassium. If the vinegar is pure, no crystalline precipitate is produced; in the contrary case, a crystalline precipitate (cream of tartar) is formed, especially by stirring.

24. The presence of tartaric acid may also be detected by saturating it with potash, or ammonia, and pouring a solution of chloride of barium, or of calcium, into the saturated solution. If the vinegar contains any tartaric acid, a precipitate, which is tartrate of lime or of baryta, will be produced.

25. If the vinegar under examination contains tartaric acid, crystals, or a crystalline pellicle will be produced during its evaporation, and by continuing the heat, an extract will be obtained as soft as treacle, and of a very acid flavour. If this extract be treated by alcohol the tartaric acid will be dissolved, and if the solution be then tested with caustic potash an abundant precipitate of cream of tartar will be produced. As, however, a slight excess of potash redissolves the precipitate, it is much better to use a cold saturated solution of chloride of potassium, of nitrate, or of neutral sulphate of potash, or better still, one of acetate of potash, an excess of which does not interfere with the production of the precipitate, especially if the mixture be vigorously stirred.

Detection of oxalic acid in vinegar.

26. Oxalic acid is said to be sometimes found in vinegar; this addition, however, must be rare, and is so much the more culpable that vinegar, the acidity of which is increased by oxalic acid, may prove poisonous; the experiments of M.M. Coindet and Christison having proved that oxalic acid in dilute solutions is rapidly absorbed, and has a most deleterious action upon the brain and spinal marrow, which

action is so much the more rapid as the acid is less concentrated. Fortunately, the presence of oxalic acid may be readily detected by saturating the vinegar with ammonia, and testing the saturated solution with one of chloride of calcium, or of sulphate of lime, or with lime-water, which will produce a precipitate of oxalate of lime. A solution of sulphate of lime is the most characteristic re-agent.

Detection of pyrolignous acid in vinegar.

27. This adulteration is very common, and may always be recognized by the empyreumatic smell and taste which is very characteristic, but which is not otherwise detrimental.

Detection of acrid substances in vinegar.

28. Pepper, capsicum, or chillies, mustard-seed, and other acrid substances are sometimes added to vinegar, for the purpose of simulating strength. The presence of these substances may be detected by saturating the acid with an alkali; the acidity of the vinegar being thus destroyed, the acrid taste of the substances employed will then become perceptible.

Detection of metallic salts in vinegar.

29. The salts occasionally met with in vinegar are principally those of copper, of lead, of zinc, and are generally referrible to the utensils employed in the manufacture of that acid. The presence of lead is detected by testing the vinegar with iodide of potassium, or with chromate of potash, both of which produce a yellow precipitate. The yellow precipitate produced by the first of these re-agents is soluble in hot water, and likewise in a large excess of the re-agent; that produced by chromate of potash is soluble in a solution of pure potash, and if digested with ammonia it becomes of a reddish or orange-red colour. In using this last re-agent it

should be applied in a dilute state. If lead is present a current of sulphuretted hydrogen will produce a black precipitate.

30. If *copper* is present sulphuretted hydrogen will also produce a black precipitate, but in that case a portion of the vinegar first decolourized by animal charcoal will be rendered blue by ammonia, and brown or crimson by ferrocyanuret of potassium.

31. The presence of *zinc* may be detected by means of ferrocyanuret of potassium, which will produce a precipitate. But the most characteristic way of detecting the presence of this metal consists in neutralizing the vinegar with ammonia, filtering, and testing the clear ammoniacal and colourless filtrate with hydrosulphuret of ammonia. If a white precipitate is produced, zinc is present. The smallest proportion, a trace of iron, is sufficient to give a grey colour to the precipitate, and if the quantity of iron present is more considerable, the precipitate is black.

32. Quantity of extract resulting from the evaporation of genuine vinegar made from wine.

33. According to Messrs. Jules Garnier and Harel, the evaporation of 1000 grains of 12 samples of pure wine-vinegar gave :—

No.	1.	1000 grains	=	Grains.
2.	”	”	=	23
3.	”	”	=	17
4.	”	”	=	22
5.	”	”	=	21
6.	”	”	=	20
7.	”	”	=	22
8.	”	”	=	20
9.	”	”	=	18
10.	”	”	=	19
11.	”	”	=	23
12.	”	”	=	17
	”	”	=	24

34. The minimum of extract produced from pure wine-vinegar is therefore 1.70 per cent., and the maximum 2.4 per cent., the average being 2.05 per cent.

35. These results may, to a certain extent, serve to indicate whether the wine-vinegar under examination is genuine or spurious, since the quantity of extract obtained from spurious vinegar is always much more considerable. Wine-vinegar yields less extract than all other vinegars, and, moreover, if its extract be treated with alcohol, it will almost entirely redissolve and leave a residuum of tartar, whilst the vinegar made from glucose, or sugar of starch, leaves, after evaporation, a residuum which is only sparingly soluble in alcohol and remains soft and glutinous.

Vinegar made from beer, cyder, perry.

36. Vinegar made from beer, cyder, or perry, may be distinguished from wine-vinegar, because they contain no tartar, and their saturating power is much inferior to that made from wine, (after deducting the sulphuric or other acids which they may contain,) so that whilst two parts of good wine-vinegar require ten parts of carbonate of soda, the same quantity of cyder-vinegar and of beer-vinegar require, the first 3.5, the second 2.5 parts of carbonate of soda.

37. The density of the best white wine-vinegar is about from 1.020 to 1.025, that of beer-vinegar is 3.20, and of cyder-vinegar about 2.0.

38. Beer-vinegar yields by evaporation 6 per cent., and cyder-vinegar 1.5 per cent. of extract; the latter has an odour of baked apples, the former has an acid and slightly bitter flavour.

39. Dr. Ure says :—"I have had occasion to examine professionally the best wine-vinegars imported in this country from Orleans, and I found their specific gravity to be above 1.019. One or two samples were supposed to contain aceti-

fied cyder. This adulteration may be tested by neutralizing the vinegar with ammonia, and then adding solution of acetate of lime. Tartrate of lime is, of course, precipitated from the wine-vinegar, while the pearly malic acid of the cyder affords no precipitate with the lime, but may be detected by acetate of lead, by the glistening pearly scales of malate of lead hardly soluble in the cold."

VENICE WHITE.—See *Carbonate of Lead*.

VITREOUS COPPER.—See *Copper-Ores*.

VITRIOL.—See *Sulphuric Acid*.

VITRIOL (BLUE).—See *Sulphate of Copper*.

VITRIOL (ROMAN).—See *Sulphate of Copper*.

VITRIOL (WHITE).—See *Sulphate of Zinc*.

VITRIOLIC ACID.—See *Sulphuric Acid*.

VOLATILE ALKALI.—See *Ammonia*.

W A T E R.

1. For certain technical and for analytical purposes, chemical or pure water is absolutely requisite, and may be obtained in that state by distillation, by which operation it is separated from the foreign substances which it may hold in solution, some of which are of a volatile nature, such as carbonic acid, oxygen, nitrogen, ammonia, nitrate and carbonate of ammonia; the others are fixed, such as salts of potash, of soda, lime, magnesia, alumina.

2. In order to obtain pure water, the distillation should be stopped when the salts, which were held in solution, begin to deposit, for if the process be continued, part of these salts might undergo decomposition and contaminate the distillate.

3. The characteristics of pure water are, that it must not produce any precipitate, or become turbid when tested by the following re-agents :—

Lime-water	.	.	{	If a precipitate or turbidness be produced, carbonic acid is present.
Baryta-water	.	.		

Chloride of barium	.	{	If a precipitate or turbidness is produced, sulphates are present.
Nitrate of baryta	.		

Nitrate of silver	.	.	{	Indicates the presence of chlorides.
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Oxalate of ammonia	.	Do. do. of salts of lime.
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Sulphuretted hydrogen	Do. do. of various metals.
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Hydrosulphuret of ammonia	.	.	{	Do. do. do.
Perchloride of mercury	.	.		

Perchloride of gold	.	{	Do. do. of organic matter.
Sulphate of zinc	.		

4. Pure distilled water evaporated upon a piece of platinum-foil should leave no residuum.

5. Pure water, we said, is obtained by distillation, yet the water distilled from rivers that run near or through populous towns, such as the water of the Thames, for example, or the Severn, the Tyne, &c., the Seine, Rhone, and Saone, &c. on the Continent, always, or generally, contain a certain quantity of carbonic acid, of ammonia, and of organic matters, which pass over with the distillate, and are subsequently found therein. The presence of these impurities, however, does not interfere with the usual analytical operations, yet it is advisable to stop when four-fifths of the water have distilled, but more especially to reject the first portions that come over.

6. Distilled water, however pure, is totally unfit to drink; for whilst, on the one hand, water which has been deprived of air by ebullition is insipid, heavy, and indigestible, the experiments of Boussingault, on the other hand, have proved clearly that the lime contained in ordinary water is a necessary ingredient, and contributes, with that contained in our food, to the formation or development of our bones.

7. Rain water contains all the substances which exist in the air, namely oxygen, nitrogen, carbonic acid, carbonate of ammonia, nitrate of ammonia, and sometimes, especially after storms, traces of nitric acid; it holds, moreover, in suspension, dust, and other minute fixed particles which are floating in the atmosphere, and which are always found in greater abundance in the first portions of rain that fall. When therefore rain-water is received into clean vessels, taking care to throw away the first portions, it may replace distilled water in most chemical operations.

8. Spring or well-water is never pure, on account of its having filtered through strata of various compositions; it contains chlorides, sulphates and carbonates of lime, of magnesia, and sometimes of potash and of alumina.

9. But who will undertake to enumerate the impurities contained in "*the water that John drinks!*"

10. To be fit for use as an ordinary beverage and culinary purposes, water should be perfectly sweet, limpid, and clear; it should readily lather with soap; when evaporated to dryness, it should leave only a small residuum, and remain for a long time transparent whilst boiling; it is only when reduced to a very small bulk by evaporation, that it should begin to become turbid; and if an alcoholic solution of soap be poured into it, a small portion of the soap only should be curded. Such water is then called soft water.

11. Hard water, on the contrary, holding in solution a large proportion of salts, is unfit for cooking and washing, because the soap is thereby converted on the surface into an insoluble margarate, stearate, and oleate of lime, and the small quantity abraded by friction, forms a curdy, insoluble precipitate.

12. Spring-water belongs to the latter class. Some spring waters contain an enormous quantity of sulphate of lime, and consequently afford a corresponding abundant precipitate when treated by oxalate of ammonia, which precipitate is oxalate of lime; and by chloride of barium, which precipitates the sulphuric acid as sulphate of baryta.

13. In order to estimate the quantity of these substances, the precipitated oxalate of lime should be collected on a filter, ignited in a platinum capsule, until all the carbon of the oxalic acid is burnt off, and the ignited residuum is weighed as carbonate of lime, into which ignition has converted it, and each grain represents 0.56292 of lime.

14. The sulphate of baryta produced by the solution of chloride of barium is also collected on a filter, washed, dried, ignited, and weighed. 117 grains of sulphate of baryta represent 40 grains of dry sulphuric acid, or each grain of sulphate of baryta represents 0.34372 grain of sulphuric acid.

15. Water which contains sulphate of lime can be rendered fit for domestic purposes by pouring a solution of carbonate of soda into it, in sufficient quantity to decompose the sulphate of lime, which produces sulphate of soda, which remains in solution, and carbonate of lime which is precipitated. The lime may also be precipitated by a solution of soap.

16. Some kinds of spring-water owe their hardness to the presence of a quantity of carbonate of lime, held in solution by an excess of carbonic acid. Some springs contain such an abundance of this salt, that any substance that may be plunged in the water soon becomes incrustated with a layer of carbonate of lime.

17. Spring-water which contains carbonate of lime in solution may be rendered fit for domestic purposes by boiling, which, expelling the excess of carbonic acid, precipitates the carbonate of lime. Or it may be simply agitated in contact with the air, which displaces and disengages the carbonic acid, and consequently determines the precipitation of the carbonate of lime. The same result is obtained by pouring into such water a certain quantity of lime-water, until the re-agent ceases to produce a precipitate. In effect, the addition of lime water saturating the excess of free carbonic acid, produces with it a neutral carbonate of lime, whilst that which existed in the solution being thus reduced into neutral carbonate, is also precipitated at the same-time.

18. The presence of bicarbonate of lime in solution may be detected, according to M. Dupasquier, by means of an alcoholic solution of logwood. If the water contains the smallest trace of bicarbonate of lime, the yellow colour of the tincture of logwood becomes purple. As, however, the presence of bicarbonate of potash, or of soda, produce the same re-action, a few drops of solution of chloride of calcium should be poured into the water to ascertain, in the absence of sulphates, whether bicarbonate of potash or

of soda is present in which case a precipitate will be produced.

19. River-water, when not contaminated by the discharge of the contents of sewers, is more pure than spring-water ; it contains the same salts as spring-water, but in less proportion, and the quantity of carbonic acid is also less in river than in spring-water.

20. Well-water is generally *harder* than spring-water, and is consequently unfit for cooking or washing, unless treated as above said.

21. The presence of oxygen in water is detected by putting a crystal of protosulphate of iron (green copperas) into a flask filled with the water under examination, which, if oxygen be present, will in a few days produce a precipitate of peroxyde of iron, of a brownish colour.

22. If the water contains carbonate, sulphate, or some other salt of iron in solution, tincture of galls, or solution of prussiate of potash are the re-agents usually employed to detect it. The first will produce in the liquid a purple-black (ink) colour or tinge; the second will produce a bluish-white colour, gradually becoming blue.

23. If lead is present, sulphuretted hydrogen will produce a black precipitate, or only a brownish tinge, if only a trace be present. Most metals can be detected in water by this re-agent ; if the 'water is' pure, a slight milkiness only will be produced by it.

24. Sea-water is bitter, salted, and has a nauseous taste ; it is altogether unfit for drinking. Its analysis by several chemists, yielded the following results :—

Substances contained in one litre* of Sea Water.	Atlantic Ocean.				Mediterranean Sea.	
	Bergman	Marcet.	Lagrange and Vogel.	Murray.	Lagrange and Vogel.	Laurent.
			Litre.		Litre.	Litre.
Carbonic acid.....	...	...	0.230	...	0.110	0.200
	grains.	grains.		grains.		
Chloride of sodium...	32.155	26.600	26.646	21.80	26.646	27.220
Ditto magnesium	8.771	5.154	5.853	4.86	7.203	6.140
Sulphate of magnesia	...	...	6.465	...	6.991	7.020
Sulphate of lime.....	1.039	...	0.150	...	0.150	0.150
Carbonate of lime } and of magnesia }	...	...	0.200	...	0.150	0.200
Chloride of calcium..	...	1.232	...	0.78	...	...
Sulphate of soda.....	...	4.660	...	3.50	...	...
Potash	...	...	...	...	...	0.010
Iodine, probably in } the state of Iodide }	...	...	...	...	...	Indefinite quantity.
of potassium..... }						
Bromine, probably } in the state of bro- }	...	...	...	...	...	Do.
mide of magnesia }						
Total.....	41.965	37.646	39.314	30.94	41.140	40.740

25. The composition of sea-water, however, is not uniform; the amount of its constituents varies according to localities. We give here the results of the analysis of the water of the English Channel by Schweitzer, and of the Mediterranean sea by Laurens :—

	English Channel.	Mediterranean.
Water	964.74372	959.26
Chloride of Sodium.....	27.05948	27.22
„ Potassium.....	0.76552	0.01
„ Magnesium ...	3.66658	6.14
Bromide of Magnesium ...	0.02929	—
Sulphate of Magnesia.....	2.29578	7.02
„ Lime	1.40662	0.15
Carbonate of Lime	0.03301	and Magnesia { 0.20
	1000.90000	1000.00

* The litre contains 51.12079 cubic inches, or 1.76377 pint.

25. M. Balard has found iodine in the water of the Mediterranean.

26. Mr. R. Phillips published the following analysis of the water of the Thames:—

Quantity of Water, 1 gall. = 10 lbs. avoirdupois at 62 Fahr., or 7000 gr. avoirdupois.	At Brentford, source of the Grand Junction Water Works Company.	At Barnes' source, of the West Middlesex Water Works Company.	At Chelsea source of the Chelsea Water Works Com- pany.
Carbonate of Lime ...	16.000	16.900	16.500
Sulphate ditto.....	3.400	1.700	2.900
Chloride of Sodium }	Very minute portion. }	Ditto }	Ditto
Oxyde of Iron.....			
Silica.....			
Magnesia.....			
Carbonaceous mat- ter.....			
Solid matter held in solution	19.400	18.600	19.400
Mechanical impurity	0.368	0.368	0.238
Total, solid matter	19.768	18.968	19.638

We may not inappropriately terminate this article by the following quotation from “Chambers’ Papers for the People,” entitled, “The Sanitary Movement :”—

“London is supplied with water by eight principal companies, and two or three minor ones, who furnish, according to Mr. Fletcher’s calculation, as read before the Statistical Society, 330,000,000 hogsheads yearly ; being 10,140,500 cubic feet per day, or at the rate of 30 gallons for each individual of the population. Yet it is notorious that there are in London 70,000 houses, occupied by more than half a million of inhabitants, which have no supply whatever. It is in this class of dwellings that the miserable make-shifts take place alluded to above, as exhibited most markedly in the east of London, where some hundreds of ‘stand-cocks’ scattered over the ‘low neighbourhoods,’ with an intermittent supply, afford but scanty means for comfort or cleanliness.

“The thirty gallons per day to each individual is thus shown to be practically a fallacy. Yet were it true, certain

essentials would still be lacking. We want water, but good water, sweet and wholesome—not diluted mud or sewer refuse. The Thames, in its course of 160 miles, receives the refuse outpourings of 223 cities, towns, and villages; the metropolis discharges its pestilential tribute to the noble river through 130 sewers, to the amount of 30,000,000 gallons daily, or 130,000 tons. Among a population of 2,000,000, the mere daily ablutions must contribute largely to the causes of contamination; add to this the excrementitious matters, the washings of foul linen, the filth and refuse of many hundred manufactories, the offal and decomposing vegetable substances from the markets, the foul and gory liquid from slaughter-houses, and the purulent abominations from hospitals and dissecting-rooms, and an idea may be formed of the quality of the fluid which no inconsiderable portion of the inhabitants of London are doomed to drink, to use for all all domestic purposes every day of their lives, unless, indeed, they abjure the impure element altogether, and consume it as disguised by brewers, distillers, and licensed victuallers.

“The Lambeth Company, which distributes water over a large part of the low, flat district on the south of the Thames, take their supply from the river near to Charing Cross Suspension Bridge; they pump it at once, without any intermediate process of filtration, into the cisterns of their customers. Now, it is worthy of remark, that during the late visitation of cholera, the deaths were more numerous on the Lambeth side of the river than in any other part. The maximum mortality fell in Rotherhithe, a district supplied with water from the Thames, near Chelsea Hospital. The whole of this peninsulated region lies low, as before stated, some feet below high-water mark—a fact not to be lost sight of in theorizing on the relation between impure water and choleraic phenomena. But when we find the more elevated districts—supplied by the New River, and the companies deriving their supplies from Hampstead and from the Thames at Kew and Hammersmith, sources of *comparative* purity—

escaping almost intact, we cannot resist the inference that bad water induces an abnormal condition in those who drink it favourable to the encroachments of disease. From time to time, a panic has seized the public mind on the subject of Thames water; and companies have filtered on a large, and individuals on a small scale, hoping to obtain a drinkable beverage. In 1828, a committee of medical and scientific gentlemen appointed by parliament drew up a report on the water question. We have quoted from this report above. As regards the mechanical cleansing, they considered it obvious, that water receiving so large a proportion of foreign matters as we know find their way into the Thames, and so far impure as to destroy fish, cannot, even when clarified by filtration, be pronounced entirely free from the suspicion of general insalubrity. Analyses of water engaged the attention of Berzelius during some of the latter years of his life: that great chemist found it impossible to divest water, once contaminated by human excretæ, of its noxious principles."

W A X.

1. Wax is a product secreted by bees; or rather, fabricated by bees from honey or sugar. It is obtained after expressing the honey from the combs by melting the latter into cakes, in which state it constitutes the yellow bees-wax of shops. Unbleached bees-wax is yellowish-brown; has an odour of honey, and is tasteless. When bleached it is perfectly white, and has a salvy odour.

2. Both yellow and white wax are often adulterated with earthy matter, such as chalk, sulphate of lime, of baryta, carbonate of baryta, &c.; or with flour, starch, rosin, oxyde of lead, of zinc, and I have met with a specimen which contained 28 per cent. of effloresced sulphate of soda.

3. Most of these admixtures may be detected by boiling the wax in water, which will separate all the heavier sub-

stances ; such as the chalk, sulphate of lime, of baryta, and other earthy matter, the oxyde of lead, of zinc, &c. Sulphate of soda will dissolve, and on cooling, the wax will be found in the solid state floating on the water.

4. If the wax has been adulterated with flour or fecula, the water in which the wax has been boiled will be more or less thick, and after cooling it will produce a blue colour with solution of iodine. Or all these impurities may be estimated directly by fusing the wax *per se* in a capsule, and on leaving it at rest the impurities will subside, and be found at the bottom of the capsule. And, moreover, if starch or flour be present, the wax being treated by concentrated sulphuric acid will turn black, because the acid will then char the starch or flour.

5. Bees-wax is sometimes adulterated by *rosin* ; this fraud may be detected because, in that case, the fracture will be smooth instead of granular, and if heat be applied, the odour of rosin becomes perceptible. That odour is sometimes readily recognized in the cold. A cotton wick, dipped into fused genuine bees-wax, burns with a clear white flame, but if rosin be present, the flame is fuliginous and smoky.

6. The adulteration of bees-wax with *tallow* is more difficult of detection, yet the presence of the latter substance may be recognized by dipping a cotton wick into the fused bees-wax under examination, lighting it, and after a few seconds blowing it out, when the odour of tallow will become perceptible. According to Boudet and Boissenot, this fraud may also be detected by submitting the suspected wax to dry distillation, for pure wax yields no sebacic acid, whilst if it contains two per cent. of tallow, sebacic acid is obtained, and may be recognized as such, because the water into which the products of the distillation have been digested, and which should be perfectly pure, has acquired the property of being precipitated by a solution of neutral acetate of lead, and also by the salts of silver and of mercury.

7. Bleached bees-wax which has been adulterated by

tallow, instead of being semi-transparent and hard, is more opaque and softer.

WHITE ARSENIC.—See *Arsenic*.

WHITE COPPER.—See *German Silver*.

WHITE COPPERAS.—See *Sulphate of Zinc*.

WHITE LEAD.—See *Carbonate of Lead*.

WHITE OXYDE OF ARSENIC.—See *Arsenic*.

WHITE VITRIOL.—See *Sulphate of Zinc*.

WHITE ZINC.—See *Oxyde of Zinc*.

W I N E S.

1. Wine is a liquid resulting from the alcoholic fermentation of the juice of the grape, but for which gooseberries, currants, or other fruits are often substituted. These are generally called British wines. Perry, cyder, mead, beer, &c., are the fermented juice of pears, apples, honey, malt, &c.

2. It often happens that wine which has been kept too long, or in a warmer place than should be, becomes acid or sour, and instead of being sold to the vinegar-maker, as it should, for it is fit for nothing else, it undergoes in the hands

of certain unprincipled dealers, a *doctoring* which, removing, neutralizing, or masking this acidity, allows of its being mixed with other wines, or with alcohol, after which it is sold to the inexperienced or incautious as genuine wine. The substances employed to neutralize the sourness of wines are *carbonate of soda*, of *potash*, or of *lime*, but as these substances give a dark, or even a black colour to the wine, and hasten the putrefactive fermentation, *litharge*, *carbonate of lead*, or *metallic lead* is sometimes employed, the result being the formation of acetate of lead (sugar of lead), which is a salt of a sweet taste, which does not alter the colour of the wine, and which, moreover, has the property of checking fermentation. This most dangerous practice, however, is much less frequent than formerly, when the poisonous properties of acetate of lead were not so well known as now, and it is to be hoped that the few cases yet met with occasionally, are the results of the ignorance of the pernicious effects of that sophistication. A quart of wine may take up 15 or 20 grains of litharge, and produce the disorder called *painter's cholic*, which generally proves fatal.

3. The above substances may be detected in wine in the following manner :—

4. When wine has been sophisticated with *carbonate of lime*, the addition of oxalate of ammonia invariably produces a precipitate of oxalate of lime. Yet, though oxalate of lime may produce such a precipitate, the operator should not hastily conclude that the wine has been saturated with carbonate of lime, because genuine wine contains tartrate of lime, and will therefore produce a precipitate of oxalate of lime when tested by oxalate of ammonia ; but in the latter case, that is, if the wine be genuine, the precipitate produced is trifling, whilst in the contrary case it is abundant. The fact may, however, be placed beyond doubt by evaporating a portion of the wine to about one-eighth of its bulk, and diluting it then with its own bulk of alcohol, which will separate the tartrate and sulphate of lime which may exist

naturally in the wine, whilst the acetate of that base remains in solution. The wine should then be filtered, and the filtrate evaporated to dryness. The dry residuum is next redissolved in water and filtered. If now the filtrate, being tested with oxalate of ammonia, produces an abundant precipitate of oxalate of lime, the presence of acetate of lime is rendered conclusive.

5. If *carbonate of potash* has been employed to saturate the excess of acetic acid, the presence of acetate of potash may be rendered manifest as follows :—A portion of the wine is evaporated to syrupy consistence and stirred with a small quantity of alcohol, which dissolves all the acetate of potash with the help of a gentle heat, and the liquor is filtered. The alcoholic filtrate, which has a yellowish-red colour, should be divided into two portions ; one of these portions is tested with solution of chloride of platinum. If this produces a granular precipitate of a lemon-yellow colour, it is a proof of the presence of potash. The second portion should be evaporated to dryness, and the dry residuum, treated by concentrated sulphuric acid, will then disengage vapours of acetic acid, recognizable by their odour. It is true, that genuine wine, containing always some acetate of potash, behaves in the same manner when so treated, but the quantity of acetate of potash existing naturally in the wine is so small, that chloride of platinum creates only a turbidness or a very slight precipitate, and the vapours of acetic acid evolved by treatment with concentrated sulphuric acid are very trifling.

6. If the wine has been saturated with *carbonate of soda*, the residuum left after evaporation should be treated by weak alcohol, in order to dissolve the acetate of soda ; and on evaporating, acetate of soda will be obtained in crystals, which, heated before the blow-pipe, will impart a deep yellow tinge to the flame, and which, when treated by concentrated sulphuric acid, will evolve pungent vapours of acetic acid.

7. If *lead*, or its *carbonate*, or *litharge* has been employed

to saturate the acid of the wine, the detection is very easy and conclusive. A portion of the wine is evaporated to dryness, the organic residuum is charred, triturated with twice its weight of nitre, and decomposed by projecting it by small portions at a time in a red-hot capsule or crucible. If the ignited mass should still have a brown colour, it should be triturated with a fresh portion of nitre and ignited again. After fusion, the residuum is treated by very dilute nitric acid in order to dissolve it, and if a portion of the solution, which is almost colourless, being treated by sulphuretted hydrogen, produces a black or dark-brown precipitate; and if another portion of the solution being tested with a solution of chromate of potash, produces a yellow precipitate, and a white one when tested by solution of carbonate, or of sulphate of potash, of soda, or by ammonia, the presence of lead is certain. The presence of lead in wine may also be detected by testing with solution of oxalic acid, the precipitate produced is collected on a filter, or separated by decantation; it is then heated upon charcoal before the blow-pipe, the first impression of the heat causes the mass to emit fumes, it becomes white, and finally a bead of metallic lead remains, which may be seen either with the naked eye, or with the help of a magnifier. Generally, however, the quantity of lead is too small to be detected in this manner.

8. The practice of rinsing wine-bottles with lead-shot is sometimes attended with serious consequences, on account of some of the shots being carelessly left in the bottles, or jammed by the shaking, in the fold or circular depression at the bottom of the bottle, where they may be left unperceived. There are several cases on record of persons having been seized with violent cholic, with all the symptoms of poisoning, from having drunk wine which had thus become deleterious, the few shots thus accidentally left, having gradually become converted into acetate and carbonate of lead.

9. As to *alum*, which is sometimes added to wine for the purpose of brightening its colour, or of clarifying newly

made wine, its presence may be detected by first decolorizing the wine (if red wine) by means of animal charcoal, previously washed with hydrochloric acid, filtering, and evaporating the liquid to about one-third of its volume, in a porcelain or platinum capsule, and again filtering it. If a precipitate has been produced whilst concentrating it, if solution of potash, or of ammonia, or of sal-ammoniac produces, when poured into the filtrate, a white precipitate soluble, with the help of heat, in an excess of solution of caustic potash ; if carbonate of potash or of soda produces a white precipitate ; if solution of nitrate of baryta, or of chloride of barium produces also a white precipitate, insoluble in water and in acids, then the wine contained alum.

10. Or a given portion of the wine may be evaporated to dryness and ignited ; the ignited residuum is then treated by a small quantity of hydrochloric acid, evaporated to dryness, again treated by dilute hydrochloric acid. If the addition of solution of caustic potash to the acid solution produces a white bulky precipitate soluble in an excess of caustic potash, but which is reprecipitated by a solution of sal ammoniac, then *alum* is present.

11. A small quantity of *sulphuric acid* is sometimes added to wines ; its presence in the free state may be detected by pouring a drop or two of the suspected wine upon a piece of paper, and drying it at a gentle heat. The wine, if pure, leaves the paper unaltered, but if it contain sulphuric acid, the paper will be corroded and crumble into fragments, on rubbing between the fingers the part which has thus been moistened.

12. M. Lassaigne says also, that pure wine leaves by spontaneous evaporation a violet or purple stain on the paper, whilst that to which sulphuric acid has been added (from 2 to 3000ths) leaves a pink stain in drying.

13. The paper best suited for such experiments is common glazed paper containing starch ; or it may be prepared by painting it as it were with thin paste.

14. But the most frequent adulteration consists in an addition of water and of alcohol. There is no satisfactory method of detecting this fraud when the wine, after having been sophisticated in this matter, has been allowed to remain undisturbed for some considerable time, and when perfectly pure sugar-spirit has been employed for the purpose. The best test in such cases is a good palate. But when the spirit employed is ordinary spirit, which is generally the case, the adulteration may be detected by distilling a portion of the wine, and rubbing between the hand a small quantity of the spirit which distils over. If the wine was pure, no other odour is discernible but that of pure spirit; in the contrary case, a peculiar odour (that of oil of grain, or fused oil) becomes apparent.

15. The quantity of alcohol contained in wine and other spirituous liquids may be summarily ascertained as follows :

Take a tube graduated into 100 parts, and fill up 50 of them with the liquor under examination; add thereto 12 or 15 measures or parts of solution of basic acetate of lead, which is made by boiling together in a glass-vessel a mixture of two ounces of pulverized litharge, three ounces of sugar of lead, and one pint of water, until the liquid is reduced to one-half of its volume. The spirituous liquor and the solution of basic acetate of lead are to be shaken together in the tube until the colour has nearly disappeared, and fused carbonate of potash, previously pulverized, is added, until it no longer dissolves and then falls at the bottom of the tube. The tube is now corked up and left at rest for some time, when the alcohol will be seen floating in a distinct stratum, which enables the operator to read off the quantity contained in the liquor. The solution of basic acetate of lead above alluded to should be kept for use in a well-corked up bottle.

16. The quantity of alcohol contained in wine may, of course, be determined also by distillation, and taking the specific gravity of the distillate. To effect this, half a pint of the wine in question is put into a small still or retort,

adapted to a Liebig's condensor, connected with a glass-balloon. The operator distils about two-thirds of the wine, and when the distillate has completely cooled, its specific gravity is then taken at 60° Fahr., by means of a 1000 grains specific gravity bottle, or otherwise. Let us suppose that on weighing the contents of the specific gravity bottle, it is found to be 960 grains ; reference to the tables given in the article on *Alcohol*, will show that spirits of specific gravity 0.960, contain 40.1 per cent. of spirit under proof, or 29 per cent of absolute alcohol of specific gravity 0.7960, and hence the quantity of alcohol contained in the wine operated upon is easily calculated.

16. Hitherto we have spoken only of the adulterations to which genuine wine is subjected ; we have now briefly to consider the simulations of wine, that is to say, the sophistications in which wine, instead of being the principal constituent, is, as it were, the adventitious substance.

17. In the "Publican's Guide," and "Licensed Victuallers' Director," the following impudent receipts are given.

"To manufacture port wine, put into a cask previously sulphurized—

12	gallons of strong Port.
6	do. Rectified Spirit.
3	do. Cognac Brandy.
42	do. Fine Rough Cyder.
63	gallons.

18. And again, another directs :—

45	gallons of Cyder.
6	do. Brandy.
8	do. Port Wine.
2	{ do. Sloes, stewed into two gallons
2	{ of water, and the liquor pressed off.
63	gallons.

“ If the colour is not good, tincture of red sanders-wood or cudbear should be added.”—Oak-bark, elder, brazil-wood, privet, beet, litmus, are all used to make these spurious wines, some of which do not even contain the smallest particle of wine.

19. These adulterations, and the colouring matter employed in making them may be detected in various ways :—First of all, when spirit has been employed in the *manufacture* of wine, it may generally be detected by the odour of the liquid, and also by that of the distillate, as we said before. If the proportion is at all considerable, as in the above receipts, its presence may be readily detected by throwing a portion of the suspected wine upon brightly ignited charcoal, when a species of deflagration will take place. If the wine is falsified with cyder or with perry, evaporate the wine at a steam-heat to a syrupy consistence, and allow the whole to cool without stirring ; at the end of 24 hours the clear liquor should be decanted from any crystals of cream of tartar which may have formed ; the decanted liquid is diluted with pure distilled water and evaporated as before. The crystals, if any have formed, are again separated by decantation, and the operation is repeated until no more crystals are formed. The syrup which is left at the end of the experiments has the characteristic taste of the apple, or of the pear.

20. We should remark also, that cream of tartar being one of the constant constituents of genuine wine, any wine in which this substance would be found wanting might at once be pronounced spurious *ipso facto* ; or if the quantity of tartar were found very much below the usual quantity, or above it, the wine might be safely considered as having been either diluted with a mixture of alcohol and water, or adulterated with cream of tartar, probably to simulate that which should have been naturally present. In order to detect the tartar and determine its proportion, proceed as follows :—Take a given quantity of the wine under examination, a pint for example, evaporate to dryness, and ignite the residuum ;

the tartar (bitartate of potash) is thereby converted into carbonate of potash, which being examined by test sulphuric acid (see *Alkalimetry*), will indicate the proportion of bitartate of potash to which the carbonate found corresponds. 1000 grains-measures of the test sulphuric acid employed, containing for example 40 grains, or one equivalent of sulphuric acid, will therefore indicate, if saturated, 180 of cream of tartar.

21. According to Chevallier, the colouring matter employed for adulterating wine may be detected by solution of caustic potash as follows :—A solution of caustic potash is to be added to the suspected wine in sufficient quantity to saturate the acid of the wine. If the colour of the wine is genuine, no precipitate will be formed, but the colour will change, first from red to bottle-green, and after some time to brownish-green, or brown. This colour differs from that produced when an artificial colouring matter has been employed, for example :—

WINE COLOURED BY THE
FOLLOWING SUBSTANCES.

COLOUR PRODUCED BY
POTASH.

Elder-berries.

Purple.

Logwood.

Reddish-purple.

Red Mulberries

Purplish.

Brazil wood.

Red.

Beet-root Juice.

Red.

Litmus.

Light Violet.

American Grape.

Yellow.

(*Phitolaca decandra*).

But none of these substances will yield the greenish, or dark-green colour which genuine wine assumes under this treatment.

22. When wine has been coloured with a decoction of the petals of the red poppy, by logwood, or by Brazil-wood, the fraud, according to the experiments of M. Jacob, may be

recognized by means of a solution of sulphate of alumina (10 parts of sulphate in 100 parts of water) mixed in equal proportions with the wine to be tested (that is to say, one fluid drachm of each), and a few drops of solution of carbonate of ammonia are then poured into the mixture. (The solution of carbonate of ammonia is made by dissolving eight parts in weight of carbonate of ammonia in 100 parts of water.) The addition of the carbonate of ammonia determines a precipitate, or imparts a tinge variously coloured to the wine, if it have been adulterated; whilst if genuine, only a greyish-white precipitate is produced, as may be seen here under:—

Pure wine.	Slightly coloured.
	Greyish-white precipitate.
Pure wine mixed with Brazil wood.	Carmine, red or pink precipitate, more or less intense, according to the extent of the adulteration.
Pure wine mixed with log-wood.	Fine dark-purple precipitate.
Pure wine, and petals of red poppies.	Slate - coloured precipitate, more or less intense.

23. Two drops of an infusion made with eight parts of one of these substances in 250 parts of water, are sufficient to produce a very clear reaction when mixed with one fluid drachm of wine.

24. Mr. Vogel proposed the solution of basic acetate of lead to detect when colouring matter has been added to wine.

Pure wine.	Greyish green.
Pure wine mixed with Brazil wood or elder-berries.	Indigo blue.
Pure wine mixed with beet-root juice or sandal-wood.	Red precipitate.
Pure Madeira wine.	Light yellow, or cream coloured precipitate.
Pure port wine.	Greyish, with a slight tinge of green.

With logwood—concentrated.	Crimson red.
Ditto diluted.	Leaden, or bluish colour.
With beet-root juice—concentrated.	Puce colour.
Ditto diluted.	Flesh colour.

25. Berzelius, however, asserts that the colour of the precipitate varies with the age of the wine tested.

26. According to M. Nees van Esenbeck, the best method of detecting the colouring matter of spurious wines consists in making two solutions; the first with one part of alum and eleven parts of distilled water; the second with one part of carbonate of potash, and eight parts of water.

A determined volume of the wine to be tested is mixed with its own bulk of the alum-solution, and carbonate of potash is gradually poured into it, taking care, however, not to decompose the whole of the alum. The alumina is thereby precipitated, but as it unites with the colouring matter of the wine, the precipitate is variously coloured, according to the species of colouring matter with which it is combined.

With pure wine.	Dingy-grey precipitate, partly soluble in an excess of the re-agent, in new wines.
Wine coloured with the petals of the red poppy.	Greyish-brown precipitate, becoming black by excess of alkali.
Wine coloured by privet-berries.	Purplish-brown precipitate.
Wine coloured by myrtle-berries.	Greyish-blue precipitate.
Wine coloured by elder-berries.	Purple precipitate.
Wine coloured by Brazil-wood.	Violet-grey.
Wine coloured by logwood.	Pink.

27. From the above table we may conclude that all those wines which, being treated by solution of alum and of carbonate of potash, yield precipitates of a blue, violet, or pink colour, may be suspected of having been artificially coloured.

WOOL.—See *Cotton*.

YELLOW SULPHURET OF ARSENIC.—See *Sulphuret of Arsenic*.

Z A F F R E.

1. Zaffre is, essentially, a combination of silica and of oxyde of cobalt; that of commerce consists of roasted cobalt-ore and quartz in fine powder, and consequently contains all the metallic oxydes which may happen to exist in the ore. A fine sample which I analysed, contained—

Oxyde of cobalt	13.5
Peroxyde of iron	35.7
Alumina	3.3
Silica	43.3
Arsenic	0.8
Water and loss	3.4
	100.0

But other samples contain only from one to three per cent. of cobalt, and from two to six per cent. of nickel, also copper, and sometimes silver.

2. The analysis of zaffre is performed like that of the ores of cobalt and of nickel; that is to say, the ore or the zaffre, previously reduced into fine powder, is treated by hydrochloric acid or by aqua regia, and the solution so obtained is filtered, in order to separate the silica, which is generally a ferruginous sand; or else the pulverized mineral may be fused with about four times its weight of carbonate of potash; the crucible containing the fused mass is placed into a large capsule, and dilute hydrochloric acid is poured upon it in

small quantities at a time and gradually, as the effervescence subsides; the large capsule is for the purpose of collecting the small portions which may be projected by the effervescence. The whole is then evaporated to dryness, the dry mass is drenched with hydrochloric acid, diluted with water, and filtered, in order to separate the silica. Whichever way the solution is effected, a stream of sulphuretted hydrogen is passed through the acid solution, and the whole is left to digest for several hours in a warm place. This will precipitate the copper, silver, and arsenic which may be present in the liquor; or, if iron be present, which is almost sure to be the case, there will be also a precipitate of sulphur from the decomposition of the sulphuretted hydrogen employed, especially if aqua regia has been used. These substances are separated by filtering, and whether the solution of the mineral has been effected by hydrochloric acid or by aqua regia, the operator must now add some nitric acid to the filtrate, previously boiling it until all odour of sulphuretted hydrogen has disappeared, in order to peroxydize the iron which is contained in the filtrate with the oxydes of cobalt and of nickel. The liquor is then neutralized by ammonia until a few flakes of peroxyde of iron begin to appear, and the precipitation is completed by a solution of neutral succinate of ammonia. The persuccinate of iron thus precipitated is collected on a filter, carefully washed, ignited, and weighed as peroxyde of iron.

4. To the liquor filtered from the persuccinate of iron a large quantity of solution of sal ammoniac is added, and it is largely diluted with well-boiled water, so that it may be free from atmospheric air; and whilst still hot, the solution is put into a flask capable of being well corked, and a solution of potash being added, the flask is corked up and left at rest until the liquor has come of a fine clear red colour. More potash should be added if necessary, until this point is attained. The precipitate consists of oxyde of nickel, which may be collected on a filter, dried, ignited, and weighed.

5. The liquor filtered from the oxyde of nickel is now treated by hydrosulphuret of ammonia, which precipitates the cobalt in the state of black sulphuret, which is collected on a filter, and washed with water containing a little hydrosulphuret of ammonia. The precipitated sulphuret on the filter is then scraped from it as completely as possible, and put into a glass-beaker, the filter is then burnt on the cover of a platinum-crucible, the ashes are added to the mass in the glass-beaker, and the whole is boiled with nitric acid until the sulphur has separated in lumps of a pure yellow colour. The liquor is then diluted with water, filtered, and the cobalt is precipitated in the state of hydrate of cobalt by a solution of potash. The precipitate is collected on a filter, washed with hot water, dried, ignited, and weighed. The hydrate of cobalt after ignition is in the state of intermediary oxyde, containing three equivalents of cobalt, and four equivalents of oxygen. When the exact quantity of cobalt contained in the hydrate is required, the ignited oxyde should be heated in a glass-bulb in a current of hydrogen gas, by which it is reduced in the state of metallic cobalt, and weighed as such. Chemists, however, are not yet in possession of any very accurate process for the analysis of *Zaffre*.—(See my edition of *Rose's Analytical Chemistry*.)

Z I N C.

SPELTER. SPELTER, OR ZINC ORES. BLENDE.
CALAMINE.

1. Zinc, or spelter, is obtained chiefly from two minerals, namely :—*blende* or *black jack*, which is a sulphuret of zinc, and *calamine*, which is a carbonate of zinc. The latter ore is the most abundant, and, consequently, the chief source from which the zinc or spelter of commerce is obtained.

2. In this country, however, *blende* is the ore generally employed.

3. The zinc or spelter of commerce, from whatever source produced, is never pure ; it contains ordinarily about one per cent. of *iron*, of *lead*, and sometimes also some *carbon*, *copper*, *cadmium* and *arsenic*.

4. The proportion of iron contained in zinc amounts sometimes to five, or six, or even eight or ten per cent., the lowest of these proportions renders it unfit for several purposes ; in that state it does not laminate well, and is almost unfit for zincing, or as it is called *galvanizing iron*.

5. These impurities are chiefly derived from the ores from which the zinc is obtained, but the iron, at least when in the large proportions above alluded to, is derived from the apparatus employed in smelting the ore by what is called the Belgian process, in which the volatilized zinc is condensed in nozzles of cast iron, into which it remains in a molten state for several hours, during which it imbibes a large quantity of iron, as above said. This process is that followed with the ores of la Vieille Montagne, and the zinc from that most extensive establishment is, therefore, always contaminated, sometimes to a great extent, by iron. In the process, called the Silesian process, followed at Stolberg, near Aix-la-Chapelle, and in Silesia, the muffles and condensers, being all made of clay, the zinc gradually dropping from the clay condensers or "*boots*," is remelted, at least at Stolberg, in clay pans, and the zinc of that establishment is on that account remarkably pure. Mr. James Graham, a few years ago, took a patent for the reduction of zinc-ores by means of an ingenious and most economical apparatus, which produces, even from blende, zinc equal or even superior in quality to that obtained from calamine by the Silesian process.

6. In order to determine the quantity of impurities contained in the metal, proceed as follows :—

7. Dissolve a certain weight, 25 grains, for example, of the metal in a slight excess of hydrochloric acid. If a black insoluble residuum is left it consists of carbon, which may be at once separated by filtering, washed, and weighed.

8. The acid filtered liquor is then treated by a current of sulphuretted hydrogen, until it smells strongly of sulphuretted hydrogen, and the whole is left for some time in a moderately warm place ; the *lead, copper, cadmium, and arsenic*, if any be present, are thereby precipitated in the state of sulphurets of these metals, and may be separated by filtering. The filtrate which contains the zinc and iron is then to be boiled until all odour of sulphuretted hydrogen has disappeared, a little nitric acid is added to peroxydize the iron, and the whole is boiled. When the liquor, which should not contain too much acid, (in which case it should be evaporated to expel the excess) has cooled, carbonate of baryta in powder is added in excess, and the whole is thoroughly stirred. The whole is left at rest, and in the course of an hour the peroxyde of iron will have entirely deposited in the state of basic carbonate of peroxyde of iron, mixed with the excess of carbonate of baryta employed. The precipitate is then collected on a filter, and washed.

9. The filtrate is now treated by dilute sulphuric acid, in order to precipitate the baryta which is held in solution, and after separating the sulphate of baryta produced by filtering, the filtrate which now contains nothing else than the oxyde of zinc, is precipitated in the state of carbonate of zinc, by pouring into it an excess of solution of carbonate of soda ; the whole is boiled, and the carbonate of zinc produced is collected on a filter, and strongly ignited by means of an argand spirit-lamp, or of my blow-pipe gas-furnace, by which the carbonic acid is expelled, and the oxyde of zinc left may then be weighed. 40 grains of oxyde of zinc contain 32 grains of metal ; or each grain of oxyde of zinc contains 0.80128 grain of zinc. The impurities may be determined by the difference of weight.

10. *Analysis of Zinc Ores.*—Many ores accidentally contain zinc, some ores, for example, in galenas (sulphuret of lead) the proportion of zinc is sometimes sufficiently considerable to allow of its being separated, which in that case is accom-

plished simply by washing, on account of the difference of the specific gravity of the blende and the galena, the two ores may be thus most rapidly and economically separated. The principal ores of zinc, as we said, are blende and calamine, and they are the only ores which are worked.

11. Blende is a native sulphuret of zinc. It is generally in amorphous masses, of a lamellar or fibrous structure, brittle, generally of a black or greenish colour, to which circumstance it owes its name of *Black Jack*; frequently, however, it has a brown or ruddy tinge, in which case it is known under the name of *ruby blende*. Sometimes also, but rarely, it is yellow.

12. Blende is rarely met with in a pure state; in general it is contaminated by *sulphurets of iron*, of *cadmium*, of *lead*, of *copper*, of *arsenic*; it may also, and does usually, contain *alumina*, *silica*, *magnesia*, and *fluoride of calcium*.

13. When blende is obtained from galena, it is important to ascertain whether it is sufficiently well prepared and duly separated from sulphuret of lead, for the latter compound has a very destructive action upon the muffles in which the reduction is effected. In a process which I contrived some time ago, however, the zinc being reduced in a smelting furnace, of a peculiar construction, the presence of lead is not objectionable. In England, well prepared blende contains sometimes as much as 92 per cent. of sulphuret of zinc, 6 per cent. of protosulphuret of iron, and 2 per cent. of earthy matter; its specific gravity is from 3.6 to 4.0. The usual contents of blende average from 50 to 52 per cent. of zinc.

14. The actual analysis of this ore is performed as follows:—

15. A weighed quantity, for example 25 grains, of the ore are reduced into very fine powder and dissolved in pure nitric acid, or aqua regia, with the help of heat. The sulphurets are thereby oxydised, a portion of the sulphur being converted into sulphuric acid, whilst another portion

separates at first in the shape of flakes of a grey colour, but which gradually, under the influence of the boiling acid, agglomerate into lumps, which ultimately assume a pure yellow colour. The digestion in the acid should be continued until this result is obtained. The whole is then thrown upon a filter, which retains not only this undissolved sulphur, but likewise the silica which was contained in the ore. These insoluble portions are then washed and dried at a gentle heat, after which, the lumps of sulphur and the silica may each be weighed separately. The sulphur, however, after weighing, should be ignited in a small counterpoised platinum crucible; if a fixed residuum remains, it consists either of the oxyde of the metal with which the sulphur was combined, or of some other insoluble matter, from the matrix or *gangue*.

16. A current of sulphuretted hydrogen is then passed through the acid filtrate; if this produces a black precipitate, *lead* or *copper* is present; if yellow, it may be *arsenic* or *oxyde of cadmium*; but whatever the precipitate, it must be separated by filtering, washed, and kept for further examination, should the operator wish to determine subsequently its nature and quantity.

17. The filtrate is now boiled until all smell of sulphuretted hydrogen has disappeared, and it is then supersaturated with ammonia. This addition of ammonia in excess will at first produce a precipitate of oxyde of zinc, and of peroxyde of iron, but the oxyde of zinc is re-dissolved by the excess of ammonia employed, whilst the peroxyde of iron is left on the filter in an insoluble state. Yet, as it retains a certain quantity of oxyde of zinc, it is advisable to redissolve at once the precipitated peroxyde of iron collected on the filter, in a little hydrochloric acid. Ammonia is then added again in sufficient quantity exactly to neutralize the acid, and as soon as a few reddish-brown flakes of peroxyde of iron begin to appear, which are not re-dissolved by heating the liquor, succinate of ammonia is added, so as to

precipitate the whole of the peroxyde of iron in the state of persuccinate of iron, which is then collected on a filter, washed, and the liquor filtered therefrom is added to that first obtained.

18. The whole mass of the filtrate which is strongly ammoniacal, *colourless*, and *clear*, is then treated by hydrosulphuret of ammonia, which precipitates the zinc in the state of sulphuret of zinc. This precipitate, which is bulky and white, must be allowed to settle completely before filtering; the liquor is then decanted, and the precipitate is thrown upon a filter. It is necessary to operate as first described, for otherwise the sulphuret of zinc would soon block up the pores of the filtering paper, and the filtering would then be exceedingly slow and tedious. By decanting or filtering the clear supernatant liquor, on the contrary, the filtering proceeds very rapidly, and is accomplished in a very short time. The precipitate should be washed with water to which a little hydrosulphuret of ammonia has been added, and then digested, whilst still moist, with the filter, in concentrated hydrochloric acid, by which it is dissolved with evolution of sulphuretted hydrogen. The whole is then left to digest in the acid until all odour of sulphuretted hydrogen has vanished, the liquor is filtered, and the filter is washed with hot water. The oxyde of zinc contained in the filtrate is then precipitated by means of carbonate of soda. As, however, the filtrate contains a large proportion of ammoniacal salts, the carbonate of soda must be added in sufficient quantity to decompose them, and the whole is evaporated to dryness in a Florence flask, inclined at an angle of about 45° , in order to avoid loss by spurting. More carbonate of soda is again added, as long as a strip of turmeric paper held in the steam issuing from the flask turns brown; or as long as white fumes are observed, when a glass rod, moistened with moderately dilute hydrochloric acid is held in the said steam or vapour.

19. The addition of carbonate of soda to the liquor does

not at first produce any precipitate, but by boiling, and as the ammoniacal salts in the solution are gradually decomposed, a white precipitate of carbonate of zinc makes its appearance. The dry mass left after evaporation, as above said, is then treated with boiling water, filtered, washed with hot water, and the carbonate of zinc on the filter is then dried, strongly ignited in a platinum crucible, and the oxyde of zinc left is then weighed.

20. The operator should not omit to test the liquor filtered from the carbonate of zinc precipitated by carbonate of soda with hydrosulphuret of ammonia, for if a bulky white precipitate were then produced, it would be a proof that all the salts of ammonia have not been decomposed, and that, consequently, the liquor contains still some zinc. In that case the small precipitate thus produced should be separated and treated as above said.

21. The earths are contained in the liquor filtered from the sulphuret of zinc produced by hydrosulphuret of ammonia.

22. *Calamine*.—This ore is the most abundant of the ores of zinc, and it often contains some silicate of zinc, carbonate of iron, of copper, iron-pyrites and galena. We give here the composition of the ores of calamine.

Constituents.	Anhydrous silicate of New Jersey.	Anhydrous silicate of la vieille Montagne.	Calamine of la vieille Montagne.	Calamine of Stolberg.	Electric calamine of Busgaw.
Oxyde of zinc	71.3	63.2	5.4	2.1	66.4
Silica	25.0	25.6	2.0	3.3	26.2
Water	„	1.0	0.6	0.8	7.4
Oxyde of manganese..	2.7	„	„	„	„
Carbonate of zinc.....	„	„	89.0	60.0	„
Oxyde of iron.....	0.7	4.8	3.9	27.0	„
Sulphuret of iron.....	„	„	„	1.4	„
Clay	„	3.4	„	3.4	„
Magnesia	„	„	„	2.0	„

23. The analysis of these ores is performed in the same

manner as for blende, except that hydrochloric acid must be employed instead of nitric acid or aqua regia.

24. *Carbonate of zinc of shops.*—The carbonate of zinc of shops often contains traces only of that substance, sulphate of baryta being often largely added thereto, and sometimes the so called *carbonate of zinc* consists altogether of sulphate of baryta, or of *carbonate of lime*, or of *sulphate of lead*, no carbonate of zinc being present. These frauds are detected by treating the sample with hydrochloric acid, which dissolves the carbonate of zinc and of lime, but leaves the sulphate of baryta or of lead. The whole is then thrown upon a filter, and to the filtrate an excess of ammonia is first added, and then some oxalate of ammonia, which precipitates the *lime* as oxalate of lime, whilst the zinc remains in solution. The oxalate of lime is separated by filtering, it is washed, dried, and ignited, in order to convert it into carbonate of lime, in which state it is weighed.

25. The ammoniacal liquor filtered from the oxalate of lime is then treated by carbonate of soda, in order to precipitate the zinc as carbonate of zinc, or it may be precipitated in the state of sulphuret of zinc by hydrosulphuret of ammonia, the process being, in that case, the same as we just described for the analysis of blende.

26. The portion which was insoluble in hydrochloric acid may be identified as sulphate of baryta, or of lead, because, on moistening it with hydrosulphuret of ammonia, it will turn black if sulphate of lead is present, otherwise it will remain white.

CHEMICAL

CLASSIFICATION AND NOMENCLATURE.

ALTHOUGH the exposition of the principles of the chemical nomenclature, of the doctrine of equivalents, and of the formulæ by which the numbers of equivalents of which chemical compounds consist is expressed, belongs properly to a Treatise of Chemistry, yet I have thought it advisable to give here, as succinctly and as clearly as possible, an account of these principles, in order that the unlearned reader may be enabled to understand the nature of the chemical reactions mentioned in several parts of the articles treated of in this book. To many, therefore, the following observations may not be found unacceptable.

All substances in nature are either simple substances or compound substances.

A simple substance is that which cannot be decomposed by any of the means at our command; such is, for example, *iron* or *gold*, from which nothing but *iron* or *gold* can be extracted.

Compound substances are the result of the combination of two or more simple bodies; such as, for example, red oxyde of mercury, which yields by heat *oxygen* gas and *quicksilver*.

In the present state of chemical knowledge, the number of simple substances is sixty-two. They are:—

Aluminium.	Carbon.	Glucinium.
Antimony (<i>Stibium</i>).	Cerium.	Gold (<i>Aurum</i>).
Arsenic.	Chlorine.	Hydrogen.
Barium.	Chromium.	Ilmenium.
Bismuth.	Cobalt.	Iodine.
Boron.	Copper.	Iridium.
Bromine.	Didimium.	Iron (<i>Ferrum</i>).
Cadmium.	Erbium.	Lanthanum.
Calcium.	Fluorine.	Lead (<i>Plumbum</i>).

Lithium.	Phosphorus.	Tellurium.
Magnesium.	Platinum.	Terbium.
Manganese.	Potassium (<i>Kalium</i>).	Thorinium.
Mercury.	Rhodium.	Tin (<i>Stannum</i>).
Molybdenum.	Ruthenium.	Titanium.
Nickel.	Selenium.	Tungsten (<i>Wolfram</i>).
Niobium.	Silicium.	Uranium.
Nitrogen.	Silver (<i>Argentum</i>).	Vanadium.
Osmium.	Sodium (<i>Natronium</i>).	Yttrium.
Oxygen.	Strontium.	Zinc.
Palladium.	Sulphur.	Zirconium.
Pelopium.	Tantalum.	

The principal compounds resulting from the combination of these simple substances with each other are, the *acids*, *oxydes*, *salts*, and the *binary compounds* (combination of two simple bodies), *in the composition of which oxygen does not enter*.

ACIDS have the property of turning tincture of litmus red, and by combining with bases—(see the word in the *Glossary*)—form *salts*.

Acids are divided into *oxacids* and *hydracids*.

OXACIDS.

OXACIDS are acids resulting from the combination of a simple substance with *oxygen*. The simple substance thus combined with oxygen is called the *radical* of the acid.

In order to name an oxacid, the termination *ic* is added to the *radical*; thus *sulphuric acid*, for example, expresses the combination of the simple body, or radical of the acid, *sulphur* with *oxygen*. One of the acid combinations of the simple body, *nitrogen* with *oxygen*, is called *nitric acid*; *chloric acid* is an oxacid consisting of chlorine and oxygen, &c.

But sometimes a simple body may combine with oxygen in several proportions to form oxacids containing, relatively, more or less oxygen. When this is the case, the termination *ous* is added to the radical, forming with oxygen an acid less oxygenated than the acid in *ic* of the same radical.

OUS is therefore the termination indicating an oxacid containing less oxygen.

IC is the termination of the acid more oxygenated.

When an oxacid is the result of the combination of a radical with less oxygen than is contained in an acid in *ous*, or in an acid in *ic*, the prefix *hypo* (from a Greek word, meaning below or under,) is used to express it; when, on the contrary, the radical combines with oxygen to form an oxacid with more oxygen than is contained in an acid in *ic*, the prefix *hyper* or *per* (meaning above) is used to designate the acid. Chlorine, for example, may combine with oxygen in five different proportions to form five different oxacids, which are called by the following names:—

Hypochlorous acid, which means, the least oxygenated of the oxacids of chlorine; it is composed of one equivalent of chlorine, and one equivalent of oxygen.

Chlorous acid, which means the oxacid of chlorine, more oxygenated than the preceding acid, but less so than the following; it is composed of one equivalent of chlorine, and three equivalents of oxygen.

Hypochloric acid, which means the oxacid of chlorine more oxygenated than the two already mentioned, but less so than chloric acid. Hypochloric acid is composed of one equivalent of chlorine, and four equivalents of oxygen.

Chloric acid means the oxacid of chlorine, more oxygenated still than either of those above mentioned; it consists of one equivalent of chlorine, and five equivalents of oxygen.

Perchloric acid means the highest degree of oxygenation of the acids of chlorine; it is composed of one equivalent of chlorine, and seven equivalents of oxygen.

HYDRACIDS.

Hydracids are acid binary compounds resulting from the combination of hydrogen with a non-metallic simple substance.

In naming an hydracid, the word *hydro* (which expresses that hydrogen is the substance which is combined with the other non-metallic body, which is called radical) is used first, followed by the name of the other non-metallic body to which the termination *ic* is added.

Hydrochloric acid is therefore an hydracid, consisting of one equivalent of hydrogen and of one equivalent of chlorine.

Hydrobromic, hydriodic acids, are hydracids, consisting of one equivalent of hydrogen and one equivalent of bromine, or of iodine.

Hydracids never consist of more than one equivalent of each constituent, that is to say, hydrogen has never yet been found capable of producing more than one hydracid of the same radical.

OXYDES.

Oxydes are binary compounds resulting from the combination of oxygen with a simple body, not an acid, and which either render blue again the tincture of litmus which has been reddened by an acid, or turn the yellow tincture of turmeric brown, or else which are without action upon both litmus and turmeric.

Some oxydes, however, have acid properties, and redden tincture of litmus; they are on that account called *metallic acids*, as will be further explained presently.

There are four classes of oxydes:—

- 1°. Basic oxydes, often called *bases*.
- 2°. Acid oxydes, sometimes called metallic acids.
- 3°. Indifferent oxydes.
- 4°. Saline oxydes.

Basic oxydes or *bases*, are oxygenated binary compounds which have the property of neutralizing acids, of turning blue again the tincture of litmus which has been reddened by an acid, of turning the yellow tincture of turmeric brown, and that of red cabbage, green.

Acid oxydes or *metallic acids* have the power of acting like acids, of neutralizing and combining with bases to form salts. Such oxydes frequently redden tincture of litmus.

Indifferent oxydes cannot combine with either acids or bases to form salts.

Saline oxydes are combinations of two oxydes of a same metal, one of which acting as an acid upon the other, which acts as a base. For example, the compound known under the name of red lead may be considered as a combination of binoxyde of lead (metallic acid) which may be called plumbic acid, (*plumbum*, lead), with

protoxyde of lead. This saline oxyde, and others of the same kind, may therefore be considered as a salt, and called *plumbate of lead*. (See below, *Salts*.)

When a simple substance combines only in one proportion with oxygen to form an oxyde, the compound is simply called oxyde of such or such radical; thus the combination of *oxygen* with *cadmium* is simply called *oxyde of cadmium*.

But when the simple body combines with several proportions of oxygen the various oxydes resulting from the combination are called, *protoxyde*, *sesquioxycde*, *binoxyde* or *deutoxyde*, *tritoxycde*, *peroxyde*, &c., which are expressive of the increasing proportions of oxygen contained in these oxydes, thus—

Protoxyde of manganese means a combination of 1 equivalent of oxygen with 1 equivalent of manganese.

Sesquioxycde of manganese means a combination of $1\frac{1}{2}$ equivalent of oxygen with 1 equivalent of manganese, or, which is the same thing, 3 equivalents of oxygen and 2 equivalents of manganese.

Binoxyde or *deutoxyde of manganese* means a combination of 2 equivalents of oxygen with 1 equivalent of manganese.

Tritoxycde of iron means the combination of 3 equivalents of oxygen with 1 of iron. This oxyde being an acid oxyde, or metallic acid, is often called *ferric acid* (*ferrum*, iron).

Peroxyde means the combination of the greatest number of equivalents of oxygen which an oxyde contains. Thus, when there are only 2 oxydes, or three oxydes of a metal, the last is often called peroxyde. The term *peroxyde* does not therefore express any particular number of equivalents of oxygen, but merely the highest degrees of oxygenation of the radical. The last or highest degrees of oxygenation of metals ordinarily produce *metallic acids*.

If, on the contrary, it is the radical which is in excess, the oxyde is called a *suboxyde*, thus—

Suboxyde of silver means a combination of 1 equivalent of oxygen with 2 of silver.

To resume—

1 equiv. of oxygen	+	2 equiv. of radical	—	Suboxyde.
1 do. do.	+	1 do. do.	—	Protoxyde.
$1\frac{1}{2}$ do. do.	+	1 do. do.	—	Sesquioxyde.
2 do. do.	+	1 do. do.	—	Binoxyde or deutoxyde.
3 do. do.	+	1 do. do.	—	Tritoxyde, &c.

SALTS.

A salt is either the combination of an acid with a base, or the combination of two substances, one of which, acting as an acid, neutralizes more or less the other, which then acts as a base.

The salt formed by the combination of an acid in IC, takes the termination ATE. Thus the salt resulting from the combination of *sulphuric acid* with *soda* (protoxyde of sodium) is called *sulphate of soda* (or sulphate of protoxyde of sodium).

Sulphate of protoxyde of iron is a salt resulting from the combination of *sulphuric acid* with *protoxyde of iron*.

The salt formed by the combination of an acid in OUS, takes the termination ITE. Thus *sulphurous acid* and *soda* will form a salt called *sulphite of soda*; *sulphurous acid* and *protoxyde of iron* will form *sulphite of protoxyde of iron*.

By the same rule we say,

Hyposulphite of protoxyde of iron, to express the combination of *hyposulphurous acid* with *protoxyde of iron*.

Hyposulphate of protoxyde of iron, to express the combination of *hyposulphurous acid* with *protoxyde of iron*.

To resume: the termination—

ATE is given to the salts formed by an acid in IC;

ITE to the salts formed by an acid in OUS.

For abbreviation sake the word oxyde is sometimes omitted in naming salts; thus, instead of saying *sulphate of protoxyde of iron*, or of *protoxyde of lead*, we say simply *sulphate of iron* or *sulphate of lead*.

An acid, however, may combine in different proportions with a

same base, and *vice versâ*, the base may combine in different proportions with an acid. Wherefore, when an acid combines with a base in such proportions that the resulting compound has neither the properties of an acid nor those of an oxyde, or base, the salt is called a *neutral* salt; such is, for example, *sulphate of potash*, which neither reddens litmus paper, nor renders blue again that which has been reddened by an acid.

If the proportion of acid is more than is contained in a neutral salt, that is, if more than one equivalent of acid has combined with one equivalent of base, the salt is called an *acid salt*, and such salts have the property of reddening litmus-paper. Though it should be observed here, that this is not a distinctive character, since the neutral salts of the heavy metallic oxydes have also that property.

The proportions between the quantity of acid and of base are expressed by the words *sesqui*, *bi* or *deuto*, *quadri*, *per*, to express that the acid exists in the salt in the proportion of one and a half, two, three equivalents of acid for one equivalent of base, thus:—

	Equiv. of Acid.		Equiv. of Base.	
Sulphate of a base	= 1	+	1	neutral salt.
Sesquisulphate	= $1\frac{1}{2}$	+	1	} acid salt.
Bisulphate	= 2	+	1	
Trisulphate	= 3	+	1	
Quadrisulphate	= 4	+	1	

Persulphate of a base, expresses that the salt contains the greatest number of equivalents of acid which can combine with one equivalent of that base. A persalt is, therefore, always an acid salt.

If, on the contrary, it is the proportion of base which predominates in the base, the salt is called a *basic salt*, and the word *sub* is prefixed to the name of the salt, thus *subacetate of lead*, *subnitrate of bismuth*, mean that these salts consist of two equivalents of oxyde of lead, or of oxyde of bismuth, and of only one equivalent of acetic, or of nitric acid. The number of equivalents of base combined with one equivalent of acid is often expressed by the words *sesquibasic*, *bibasic*, *tribasic*, &c., thus *bibasic chromate of lead* is the name of a salt consisting of two equivalents of protoxyde of lead and one equivalent of chromic acid.

When a non-metallic body combines with a metal to form a

compound which is neither acid nor basic, the termination *uret* is added to the non-metallic body, thus :—

Sulphuret of iron,
Sulphuret of mercury,
Carburet of iron,
Arseniuret of potassium,

mean a combination of sulphur with iron or mercury ; of carbon with iron ; of arsenic with potassium.

Formerly, the simple bodies were divided into supporters of combustion, and combustible bodies. The substances called supporters of combustion were oxygen, iodine, chlorine, bromine and fluorine ; and although such a division can no longer be retained, the analogy of the word *oxide* has been retained in this country to express the combinations of these bodies, namely ;—iodine, chlorine, bromine, and fluorine with other non-metallic bodies, or with metals ; and, therefore, whilst the continental chemists say :—

Chloruret,	}	the English say	}	Chloride,
Ioduret,				Iodide,
Bromuret,				Bromide,
Fluoruret,				Fluoride.

With this slight difference in the termination of the compound, if the non-metallic body is capable of combining with the other body in several proportions, these proportions are expressed, as for oxydes, by the words *proto*, *sesqui*, *bi* or *deuto*, *tri*, *quadro*, *penta*, &c., to express that one, one and a half, two, three, four, five equivalents of a non-metallic body are combined with one equivalent of another simple body, thus :—

		Sulphur. + Potassium.			
		{			
Protosulphuret of potassium	=	1	equiv.	+	1 equiv.
Sesquisulphuret	do.	1½	do.	+	1 do.
Bi or deutosulphuret	do.	2	do.	+	1 do.
Trisulphuret	do.	3	do.	+	1 do.
Quadrosulphuret	do.	4	do.	+	1 do.
Pentasulphuret	do.	5	do.	+	1 do.

In the same way—

		Chlorine. + Tin.			
Protochloride of tin	=	1	equiv.	+	1 equiv.
Bi or deutochloride	do	2	do.	+	1 do.

SULPHOSALTS.

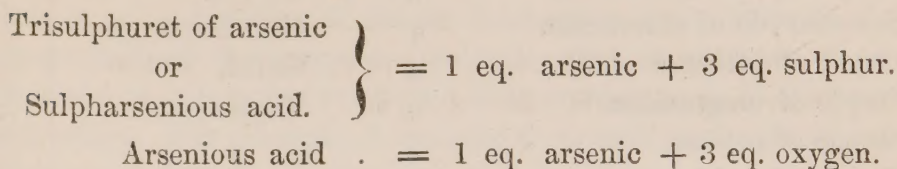
Sulphosalts are compounds resulting from the combination of certain sulphurets with other sulphurets, such are, for example, *sulphuret of carbon*, and *sulphuret of arsenic*, which can combine with *sulphuret of potassium*. Such combinations are called *sulphocarbonate of potash*, and *sulpharsenate* and *sulpharsenite of potash*. These names, now generally adopted, are, however, very objectionable, because they are contrary to the spirit of the nomenclature, since they would lead to believe that these compounds consist of sulphur, carbon, and potash ; or sulphur, arsenic, and potash, or rather of some oxacid containing sulphur, called sulphocarbonic acid, or sulpharsenic, or sulpharsenious acid with potash ; whilst in reality the above compounds are the result of the combination of *sulphuret of potassium* with *sulphuret of carbon*, or with *pentasulphuret of arsenic*, or with *trisulphuret of arsenic*.

The *pentasulphuret of arsenic*, (one equivalent of arsenic + five of sulphur) however, has been called sulpharsenic acid ; because the number of equivalents of sulphur in that sulphuret is the same as that of oxygen in arsenic acid, namely, one equivalent of arsenic + five of oxygen, thus:—

Pentasulphuret of arsenic	}	= 1 eq. arsenic + 5 eq. sulphur.
or		
Sulpharsenic acid	}	
Arsenic acid		= 1 eq. arsenic + 5 eq. oxygen.

In the same manner *trisulphuret of arsenic* (one equivalent of arsenic + three equivalents of sulphur) has been called *sulpharsenious acid*, because the number of equivalents of sulphur in that

sulphuret is the same as that of oxygen in arsenious acid, namely, one equivalent of arsenic + three equivalents of sulphur, thus:—



Chlorides, bromides, and iodides sometimes combine together and form salts, which may be assimilated to the sulphosalts; thus the combination of *chloride of gold* with *chloride of potassium* is called *chloro-aurate of potash*. The combination of *chloride of platinum* with *chloride of potassium* is called *chloro-platinate of potash*; they are also called *potassio-chloride of gold*, and *potassio-chloride of platinum*, and likewise *double chloride of potassium and gold*; *double chloride of potassium and platinum*, &c.

ALLOYS.

The compounds which result from the combination of the metals with each other are called ALLOYS, but when *mercury* forms part of the alloy the compound is called an AMALGAM.

Alloy of gold and silver means, therefore, a combination of gold with silver.

Amalgam of lead means a combination of mercury and lead.

EXCEPTIONS TO THE NOMENCLATURE.

Protoxyde of hydrogen is usually called Water.

Deutoxyde or	} of hydrogen	,,	Oxygenated water
binoxyde or			
peroxyde			
Nitroguret of hydrogen		,,	Ammonia.
Nitroguret of carbon		,,	Cyanogen.
Hydrosulphuric acid		,,	Sulphuretted hydrogen.
Hydrochloric acid		,,	Muriatic acid.
Silicic acid		,,	Silica.

Sesquioxysde of zirconium is usually called	Zirconia.	} Earths, or earthy metals.
Sesquioxysde of glucinum	Glucina.	
Sesquioxysde of aluminium	Alumina, or clay.	
Oxyde of yttrium	Yttria.	
Oxyde of magnesium	Magnesia.	
Oxyde of erbium.	"	
Oxyde of terbium.	"	
Oxyde of pelopium.	"	
Oxyde of niobium.	"	
Oxyde of cerium.	"	
Oxyde of lanthanum.	"	
Oxyde of didymium.	"	
Protoxyde of calcium	— Lime.	} alkaline earths.
Protoxyde of barium	— Baryta.	
Protoxyde of strontium	— Strontia.	
Protoxyde of potassium	— Potash.	} alkalies.
Protoxyde of sodium	— Soda.	
Protoxyde of lithium	— Lithia.	

HYDRATE is the name given to the compounds resulting from the combinations of water, in definite proportions, with acids, bases, and salts. Thus phosphoric acid in combining with water forms 3 hydrates, which are respectively called monohydrated, deuto or bihydrated, ter or trihydrated phosphoric acid, meaning that 1 equivalent of phosphoric acid is combined with 1, 2, 3 equivalents of water.

Cyanide is the name given to the combinations corresponding to the chlorides, &c. *Protocyanide*, *bicyanide*, mean a combination of 1 equivalent, 2 equivalents of cyanogen with 1 equivalent of another simple body.

ON CHEMICAL EQUIVALENTS, SYMBOLS, AND NOTATION OF BODIES.

From a careful examination of bodies, chemists conceive them to consist of infinitely small particles, which have been called *molecules* or *atoms*.

The constitution of a *molecule* or *atom* varies, of course, with the kind of substance : thus, for example, the molecule of a simple body is of necessity composed of simple molecules, and as a compound body is a combination of simple substances, each molecule of a compound body is a compound molecule, that is, contains all the elements of which the compound body consists, and in the same proportion. For example, if we take *iron*, each molecule of iron consists of parts of a similar kind, namely, of iron ; but if we take *oxyde of iron* (oxygen and iron), each molecule of that compound will consist of oxygen and iron, and in the same proportions.

Now the name of *chemical equivalent* has been given to the numbers which represent the weights, or weighable portions of the various substances which may completely replace each other in chemical combinations.

For example, if we take 40 parts in weight of pure anhydrous sulphuric acid, or any quantity of aqueous sulphuric acid containing exactly 40 parts in weight of anhydrous sulphuric acid, and add thereto lime, or magnesia, or soda, or potash, or baryta, or oxyde of lead, &c., &c., or, in fact, any other base ; until the acid is completely saturated or neutralized, we find that the quantity of each of the bases required to obtain that effect will be as follows :—

Lime	.	.	28 parts in weight.	} Saturate or neutral- ize exactly 40 parts in weight of pure, dry sulphuric acid.
Magnesia	.	18	do.	
Soda	.	32	do.	
Potash	.	48	do.	
Baryta	.	77	do.	
Oxyde of lead		112	do.	

And, therefore, the result will be 28 of lime + 40 of sulphuric acid = 68 of sulphate of lime, thus :

And so on with the other bases.

Since, then, various weights of bases exactly saturate a uniform weight of sulphuric acid, which is represented by 40, they are said to be the *equivalent* weights of that quantity of acid ; that is to say, the weight of sulphuric acid being 40, and the weight of lime necessary to saturate that quantity of acid being 28, these numbers, 40 and 28, are respectively called the equivalents of these substances, because they are capable, in these proportions, of saturating each other exactly ; and for the same reason, the equivalent of sulphate of lime, for example, resulting from the combination, is said to be 68. If the operator were to pour a quantity of liquid containing 45 parts in weight, for example, of pure anhydrous sulphuric acid upon 18 parts in weight of magnesia, he would have—

1 equivalent of magnesia	.	.	= 18
+ 1 equivalent of sulphuric acid	.	.	= 40
= 1 equivalent of sulphate of magnesia			58

And 5 parts in weight of sulphuric acid would be left in excess, that is to say, uncombined, or what is called, in a *free state*.

In the same manner, if the operator were to put, for example, 20 grains, or lbs., or cwts. of magnesia into water containing 40 grains, or lbs., or cwts. of pure dry sulphuric acid, he would have—

1 equivalent of magnesia	.	.	18 gr., lbs., or cwts.
1 equivalent of sulphuric acid	.	.	40 do. do. do.
1 equivalent of sulphate of magnesia			58 do. do. do.

And, therefore, 2 grains, lbs., or cwts. of magnesia would be left in excess, that is, uncombined, or in the *free state*.

Lime (protoxyde of calcium) consists of 1 equivalent of calcium combined with 1 equivalent of oxygen ; *magnesia* is likewise a combination of 1 equivalent of magnesium with 1 equivalent of oxygen, and so forth. Now, the equivalent of oxygen is 8, that is to say, 8 grains, lbs., or cwts. of oxygen combine as follows, with the metals here mentioned.

1 equivalent.		1 equivalent.		1 equivalent.
20 calcium	+	8 oxygen	=	28 lime.
10 magnesium	+	8 do.	=	18 magnesia.
24 sodium	+	8 do.	=	32 soda.
40 potassium	+	8 do.	=	48 potash.
69 barium	+	8 do.	=	77 baryta.
104 lead	+	8 do.	=	112 protoxyde of lead.

And consequently—

1 equivalent.		2 equivalents.		1 equivalent.
104 lead	+	16 oxygen	=	120 of binoxyde of lead.

From these explanations the reader may now conceive that the equivalents of substances, for example, that of simple bodies, is known from the determination of the ponderable quantities, that is, the respective weights of such bodies which may replace each other in saline compounds without altering their neutralization, or from the quantity of oxygen which they may absorb, or which may be replaced by another non-metallic body. For example, experience has shown that 8 parts in weight of oxygen (1 equivalent) may combine with—

1 equivalent.		1 equivalent.
69 of barium	to form	77 of oxyde of barium (baryta).
71 of bismuth	„	79 of oxyde of bismuth.
6 of carbon	„	14 of oxyde of carbon.
30 of cobalt	„	38 of oxyde of cobalt.
108 of silver, &c.	„	112 of oxyde of silver, &c.

But let us suppose, now, that we should wish to convert these oxydes into sulphurets; it is evident that we must replace the quantity of oxygen (namely, eight parts in weight, which is the equivalent of oxygen) by a certain quantity of sulphur, sufficient to take up and combine with the whole of the simple body. On trying this, it has been found by experiment, that the quantity of

sulphur required to convert the above weights of these substances into sulphurets, was 16 ; or in other words, that 16 parts in weight of sulphur were required to form 1 equivalent of sulphuret of each of the said substances, thus—

1 equivalent.		1 equivalent.		1 equivalent.
69 barium	+	16 sulphur	=	85 sulphuret of barium.
71 bismuth	+	16 do.	=	87 do. bismuth.
6 carbon	+	16 do.	=	22 do. carbon.
30 cobalt	+	16 do.	=	46 do. cobalt.
108 silver	+	16 do.	=	124 do. silver.
40 potassium	+	16 do.	=	56 do. potassium.

The equivalent of oxygen being 8, that of sulphur being 16 (or double the weight of the equivalent of oxygen), it is evident, that by the simple fact of changing 1 equivalent of oxyde into 1 equivalent of sulphuret, the equivalent of each sulphuret will weigh 8 parts in weight more than the same equivalent of each respective oxyde.

In the same manner—

1 equivalent.		1 equivalent.		1 equivalent.
108 of silver	will take	8 of oxygen	to form	116 of oxyde of silver.
		16 of sulphur	„	124 of sulphuret do.
		36 of chlorine	„	144 of chloride do.
		127 of iodine, &c.	„	135 of iodide do.

And the above quantities of oxygen, of sulphur, of chlorine, and of iodine, will respectively combine with 108 of silver, 40 of potassium, 69 of barium, 71 of bismuth, &c., in the following manner :—

1 equivalent.		1 equivalent.		1 equivalent.
8 of oxygen	+	104 lead	=	112 of oxyde of lead.
16 of sulphur	+	40 potassium	=	56 of sulphuret of potassium.
36 of chlorine	+	69 barium	=	105 of chloride of barium.
127 of iodine	+	108 silver	=	235 of iodide of silver.
75 arsenic, &c.	+	30 cobalt, &c.	=	105 of arseniuret of cobalt.

Since then these quantities are equivalent to each other, that is, may exactly replace each other in chemical combinations, they are

said to be the respective equivalents of oxygen, sulphur, silver, chlorine, iodine, arsenic, &c. The above numbers are referred to a standard, which is *hydrogen* taken as the unit, that is to say, taking the equivalent of hydrogen as 1, the equivalent of oxygen is 8, that of carbon 75, of iron 28, of mercury 100, of soda 24, &c., &c. On the continent, oxygen is taken as the unit, and therefore, in that scale, oxygen being 1, hydrogen is 12.50, carbon 75, iron 350, mercury 12.50, &c. In order to reduce the numbers of the oxygen scale to the hydrogen scale, divide the equivalent according to the oxygen scale by 12.5, the result is the equivalent according to the hydrogen scale; and *vice versa*, multiply the equivalent according to the hydrogen scale by 12.5, the result is the equivalent according to the oxygen scale. We give here a list of all the simple substances at present known, with their equivalents on both scales, and their symbols.

Names of Simple Bodies.	Symbols	Hydrogen = 1.		Oxygen = 100. H = 12.50	Oxygenated Compounds.
Aluminium	Al	13.67	In whole Numbers. 13	170 90	Al ₂ O ₃ Alumina.
Antimony (<i>Stibium</i>)..... }	Sb	64 52	65	806.45	{ Sb ₂ O ₃ Sesquioxide of antimony. Sb ₂ O ₄ Antimonious acid. Sb ₂ O ₅ Antimonic acid.
Arsenic.....	As	75.0	.....	937.50	{ As O ₃ Arsenious acid. As O ₅ Arsenic acid.
Barium	Ba	68 64	69	858.00	{ Ba O Baryta. Ba O ₂ Peroxide of barium
Bismuth.....	Bi	70.95	71	886.92	{ Bi ₂ O ₃ Sesquioxide of bis- muth. Bi ₂ O ₅ Bismuthic acid.
Boron	B	22.67	22	272.41	B O ₆ Boracic acid.
Bromine	Br	80.0	.....	1000.00	Br O ₅ Bromic acid.
Cadmium	Cd	55.74	56	696.77	Cd O Oxide of cadmium.
Calcium.....	Ca	20.0	.....	250.00	{ Ca O Lime. Ca O ₂ Binoxide of cal- cium.
Carbon... ..	C	6.0	.....	75.00	{ C O Oxide of carbon. C O ₂ Carbonic acid.
Cerium.....	Ce	46.0	.....	575.00	{ Ce O Oxide of cerium. Ce ₂ O ₃ Sesquioxide of ce- rium.

Names of Simple Bodies.	Symbols.	Hydrogen = 1.		Oxygen = 100. H = 12.50.	Oxygenated Compounds.
			In whole Numbers.		
Chlorine	Cl	35.45	36	443.20	$\left\{ \begin{array}{l} \text{Cl O}_3 \text{ Chlorous acid.} \\ \text{Cl O}_4 \text{ Hypochloric acid.} \\ \text{Cl O}_5 \text{ Chloric acid.} \\ \text{Cl O}_7 \text{ Perchloric acid.} \end{array} \right.$
Chromium.....	Cr	26.28	27	328.50	$\left\{ \begin{array}{l} \text{Cr O Protoxyde of chromium.} \\ \text{Cr}_2 \text{ O}_3 \text{ Sesquioxyde of chromium.} \\ \text{Cr O}_3 \text{ Chromic acid.} \\ \text{Cr}_2 \text{ O}_7 \text{ Perchromic acid.} \end{array} \right.$
Cobalt.....	Co	29.48	30	368.65	$\left\{ \begin{array}{l} \text{Co O Protoxyde of cobalt.} \\ \text{Co}_2 \text{ O}_3 \text{ Sesquioxyde of cobalt.} \end{array} \right.$
Copper (<i>Cuprum</i>)	Cu	31.64	32	395.60	$\left\{ \begin{array}{l} \text{Cu}_2 \text{ O Suboxyde of copper.} \\ \text{Cu O Protoxyde of copper.} \\ \text{Cu O}_2 \text{ Peroxyde of copper.} \end{array} \right.$
Didimium.....	Di	.....	.....	.....	
Erbium.....	Er	.....	.....	.....	
Fluorine	Fl	18.83	18	235.43	
Glucinium	Gl	69.69	.....	87.12	Gl ₂ O ₃ -lucina.
Gold (<i>Aurum</i>).....	Au	98.22	100	1227.75	$\left\{ \begin{array}{l} \text{Au}_2 \text{ O Suboxyde of gold.} \\ \text{Au O Protoxyde of gold.} \end{array} \right.$
Hydrogen	H	1.0	.....	12.50	$\left\{ \begin{array}{l} \text{H O Water.} \\ \text{H O}_2 \text{ Binoxyde of hydrogen.} \end{array} \right.$
Ilmenium.....	Il	.....	.....	.....	
Iodine.....	I	126.88	126	1586.00	$\left\{ \begin{array}{l} \text{I O}_3 \text{ Iodous acid.} \\ \text{I O}_4 \text{ Hypoiodic acid.} \\ \text{I O}_5 \text{ Iodic acid.} \\ \text{I O}_7 \text{ Heptaiodic acid} \end{array} \right.$
Iridium	Ir	98.06	98	1232.08	$\left\{ \begin{array}{l} \text{Ir O Protoxyde of iridium.} \\ \text{Ir O}_2 \text{ Binoxyde of iridium.} \end{array} \right.$
Iron (<i>Ferrum</i>).....	Fe	28.0	.....	350.00	$\left\{ \begin{array}{l} \text{Fe O Protoxyde of iron.} \\ \text{Fe}_2 \text{ O}_3 \text{ Sesquioxyde of iron.} \\ \text{Fe O}_3 \text{ Ferric acid.} \end{array} \right.$
Lanthanum	La	48.0	.....	600.00	$\left\{ \begin{array}{l} \text{Ln O Protoxyde of lanthanum.} \end{array} \right.$
Lead (<i>Plumbum</i>)...	Pb	103.56	104	1294.50	$\left\{ \begin{array}{l} \text{Pb}_2 \text{ O Suboxyde of lead.} \\ \text{Pb O Protoxyde of lead.} \\ \text{Pb O}_2 \text{ Plumbic acid.} \\ \text{(Brown oxyde.)} \end{array} \right.$
Lithium	Li	6.53	6	81.66	Li O Lithia.
Magnesium	Mg	12.65	12	158.14	Mg O Magnesia.

Names of Simple Bodies.	Symbols.	Hydrogen = 1.		Oxygen = 100. H = 12.50	Oxygenated Compounds.
			In whole Numbers.		
Manganese.	Mn	27.57	28	344.68	$\left\{ \begin{array}{l} \text{Mn O Protoxyde of man-} \\ \text{ganese.} \\ \text{Mn}_3 \text{ O}_4 \text{ Red oxyde of} \\ \text{manganese.} \\ \text{Mn}_2 \text{ O}_3 \text{ Sesquioxide of} \\ \text{manganese.} \\ \text{Mn O}_2 \text{ Binoxide of man-} \\ \text{ganese.} \\ \text{Mn O}_3 \text{ Manganic acid.} \\ \text{Mn}_2 \text{ O}_7 \text{ Permanganic acid} \end{array} \right.$
Mercury (<i>Hydrar-</i> <i>gicum</i>)	Hg	100.0	.....	1250.00	$\left\{ \begin{array}{l} \text{Hg}_2 \text{ O Suboxyde of mer-} \\ \text{cury.} \\ \text{Hg O Protoxyde of mer-} \\ \text{cury.} \end{array} \right.$
Molybdenum....	Mo	47.68	48	596.10	$\left\{ \begin{array}{l} \text{Mo O Protoxyde of mo-} \\ \text{lybdenum.} \\ \text{Mo O}_2 \text{ Binoxide of mo-} \\ \text{lybdenum.} \\ \text{Mo O}_3 \text{ Molybdic acid.} \end{array} \right.$
Nickel	Ni	29.54	29	369.33	$\left\{ \begin{array}{l} \text{Ni O Protoxyde of nickel.} \\ \text{Ni}_2 \text{ O}_3 \text{ Sesquioxide of} \\ \text{nickel.} \end{array} \right.$
Niobium... ..	Nb	.....	.....	.....	
Nitrogen.....	N	14.0	.....	175.00	$\left\{ \begin{array}{l} \text{N O Protoxyde of nitro-} \\ \text{gen.} \\ \text{N O}_2 \text{ Binoxide of nitro-} \\ \text{gen.} \\ \text{N O}_3 \text{ Nitrous acid.} \\ \text{N O}_4 \text{ Hyponitric acid.} \\ \text{N O}_5 \text{ Nitric acid.} \end{array} \right.$
Osmium	Os	99.40	100	1242.62	$\left\{ \begin{array}{l} \text{Os O Peroxyde of osmium.} \\ \text{Os}_2 \text{ O}_3 \text{ Sesquioxide of os-} \\ \text{mium} \\ \text{Os O}_2 \text{ Binoxide of osmium} \\ \text{Os O}_3 \text{ Osmious acid.} \\ \text{Os O}_4 \text{ Osmic acid.} \end{array} \right.$
Oxygen	O	8.0	.....	100.00	
Palladium....	Pd	53.23	54	665.47	$\left\{ \begin{array}{l} \text{Pd O Protoxyde of palla-} \\ \text{dium.} \\ \text{Pd O}_2 \text{ Binoxide of palla-} \\ \text{dium.} \end{array} \right.$
Pelopium	Pp	.....	.....	.....	
Phosphorus	Ph	32.0	.....	400.00	$\left\{ \begin{array}{l} \text{Ph}_2 \text{ O Red oxyde of phos-} \\ \text{phorus.} \\ \text{Ph O Hypophosphorous} \\ \text{acid.} \\ \text{Ph O}_3 \text{ Phosphorous acid.} \\ \text{Ph O}_5 \text{ Phosphoric acid.} \end{array} \right.$
Platinum	Pt	98.56	99	1232.08	$\left\{ \begin{array}{l} \text{Pt O Protoxyde of plati-} \\ \text{num.} \\ \text{Pt O}_2 \text{ Binoxide of plati-} \\ \text{num.} \end{array} \right.$
Potassium (<i>Ka-</i> <i>lium</i>).....	K	39.06	40	489.30	$\left\{ \begin{array}{l} \text{K}_2 \text{ O Suboxyde of potas-} \\ \text{sium.} \\ \text{K O Potash.} \\ \text{K O}_3 \text{ Peroxyde of potas-} \\ \text{sium.} \end{array} \right.$

Names of Simple Bodies.	Symbols.	Hydrogen = 1.		Oxygen = 100. H = 12.50.	Oxygenated Compounds.
Rhodium	Rh	52.15	In whole Numbers. 52	651.96	{ Rh O Protoxyde of rhodium. Rh ₂ O ₃ Sesquioxycde of rhodium.
Ruthenium	Ru	32.11	32	651.39	{ Ru O Protoxyde of ruthenium. Ru ₂ O ₃ Sesquioxycde of ruthenium. Ru O ₂ Binoxycde of ruthenium.
Selenium	Se	39.62	40	495.28	{ Se O ₂ Selenious acid. Se O ₃ Selenic acid.
Silicium	Si	21.35	22	266.82	Si O ₃ Silicic acid, or silica.
Silver (<i>Argentum</i>)	Ag	107.90	108	1349.01	{ Ag ₂ O Suboxyde of silver. Ag O Protoxyde of silver. Ag O ₂ Binoxycde of silver.
Sodium (<i>Natrum</i>).....	Na	22.97	24	287.17	{ Na ₂ O Suboxyde of sodium Na O Soda. Na ₂ O ₃ Sesquioxycde of sodium.
Strontium.....	St	43.84	44	548.00	{ St O Strontia. St O ₂ Binoxycde of strontium.
Sulphur.....	S	16	.....	200.00	{ S ₂ O ₂ Hyposulphurous acid. S ₃ O ₅ Sulphyposulphuric acid. S ₄ O ₅ Bisulphuretted hyposulphuric acid. S ₅ O ₅ Pentathionic acid. S O ₂ Sulphurous acid. S ₂ O ₅ Hyposulphuric acid. S O ₃ Sulphuric acid.
Tantalum.....	Ta	91.86	92	1148.36	{ Ta O Oxyde of tantalum. Ta ₂ O ₃ Tantallic acid.
Tellurium.....	Te	66.14	66	801.76	{ Te O ₂ Tellurous acid. Te O ₃ Telluric acid.
Terbium.....	.....	.....	.....	.....	
Thorium.....	Th	67.50	68	843.86	Th O Thorina.
Tin (<i>Stannum</i>).....	Sn	58.82	58	735.29	{ Sn O Protoxyde of tin. Sn O ₂ Stannic acid.
Titanium	Ti	25.17	26	314.70	{ Ti O Protoxyde of titanium Ti ₂ O ₃ Sesquioxycde of titanium. Ti O ₂ Titanic acid.
Tungsten (<i>Wolfram</i>).....	W	95.06	95	1188.36	{ W O ₂ Oxyde of tungsten. W O ₃ Tungstic acid.
Uranium.....	U	60.0	.....	750.00	{ U O Protoxyde of uranium U ₂ O ₃ Sesquioxycde of uranium.

Names of Simple Bodies.	Symbols.	Hydrogen = 1.		Oxygen = 100. H = 12.50.	Oxygenated Compounds.
			In whole Numbers.		
Vanadium	Va	68.46	68	855.84	{ Va O ₂ Oxyde of vanadium. Va O ₃ Vanadic acid.
Yttrium	Y	32.18	32	402.31	Y O Yttria.
Zinc	Zn	32.52	32	406.50	{ Zn O Protoxyde of zinc Zn O ₂ Binoxyde of zinc.
Zirconium	Zr	33.57	34	419.73	Zr ₂ O ₃ Zirconia.

Compounds being combinations of simple bodies, by adding together the number of equivalents which constitute the compound, the *equivalent* of the compound becomes known. For example, sulphuric acid is a compound consisting of one equivalent of sulphur combined with three equivalents of oxygen; now the equivalent of sulphur being 16, and that of oxygen 8, the equivalent of sulphuric acid is $16 + 8 \times 3 = 24$, thus:—

1 equivalent of sulphur	.	=	16
3 equivalents of oxygen (8×3)	.	=	24
1 equivalent of sulphuric acid	.	=	40

The equivalent of sulphuric acid therefore is 40.

In the same manner, soda (oxyde of sodium) consists of one equivalent of sodium, and of one equivalent of oxygen. Now, the equivalent of sodium is 24, and that of oxygen is 8, therefore $24 + 8 = 32$, thus:—

1 equivalent of sodium	.	=	24
1 equivalent of oxygen	.	=	8
1 equivalent of soda	.	=	32

Sulphate of soda is a compound, consisting of one equivalent of sulphuric acid, and of one equivalent of soda. Now, the equivalent of sulphuric acid, we have just seen is 40, and the equivalent of

soda is 32, which, added together, makes 72 as the equivalent of sulphate of soda, thus:—

1 equivalent of sulphuric acid	.	=	40
1 equivalent of soda	.	=	32
1 equivalent of sulphate of soda	.	=	72

By referring to the above table, we find the equivalent of aluminium stated 13, what is the equivalent of alumina? If we know the composition of alumina, that is, if we know that it consists of two equivalents of aluminium and three equivalents of oxygen, the answer is 37, for

2 equivalents of aluminium ($= 13 \times 2$)	=	26
3 equivalents of oxygen ($= 8 \times 3$)	.	= 24
1 equivalent of alumina	.	= 50

The equivalent of alumina is therefore 50.

What is the equivalent of boracic acid? Boracic acid consists of one equivalent of boron, and six equivalents of oxygen, therefore

1 equivalent of boron	.	=	22
6 equivalents of oxygen ($= 8 \times 6$)	.	=	48
1 equivalent of boracic acid	.	=	70

What is the equivalent of sesquioxide of bismuth? Sesquioxide of bismuth consists of two equivalents of bismuth, and three of oxygen, therefore

2 equivalents of bismuth ($= 71 \times 2$)	.	=	142
3 equivalents of oxygen ($= 8 \times 3$)	.	=	24
1 equivalent of sesquioxide of bismuth	.	=	166

The third column of the table (page 625) marked hydrogen = 1, Prout, expresses the number of the equivalents of substances on the

hydrogen scale, but represents the equivalents of hydrogen as contained a whole number of times in the equivalents of the other simple bodies. This hypothesis of Dr. Prout, within the last few years received a new impetus, and was verified for a certain number of substances by Dumas, and other eminent chemists, who ascertained that the equivalents of these bodies were multiples in whole numbers of that of hydrogen. It is impossible to say whether Dr. Prout's system is applicable to all the simple bodies, especially to those the equivalent of which is heavy, as for example, lead, and nearly all the other metals; but it is certain that its simplicity renders it extremely convenient, as it obviates the use of fractions, which are so difficult to commit to memory.

In the second column of the table given at page 625, certain letters may be observed, namely;—Al—Sb—As—Ba., &c., &c. These are abbreviations, or symbols of the names of the simple bodies, which are thus represented by the first capital letter of their Latin name. It may be remarked that when the names of two or more substances begin by the same letter, a second ordinary or Roman letter is added in order to distinguish them, thus:—

Boron is represented by B			
Barium	„	„	Ba
Bismuth	„	„	Bi
Bromine	„	„	Br

These symbols not only are representative of the name of the substance, but at the same time also they express that it is one equivalent only of the substance. By placing figures sometimes before, sometimes after, these symbols, chemists are enabled to express rapidly the number of equivalents which may be contained in any compound; for example, H stands for one equivalent of hydrogen, and Cl for one equivalent of chlorine, but when they are put together, thus, HCl, the *notation* or *formula* expresses that one equivalent of hydrogen has combined with one equivalent of chlorine to form hydrochloric acid, and therefore HCl means one equivalent of hydrochloric acid.

In the same manner the *formula* or notation of Baryta (protoxyde of barium) is BaO; that is, a combination of one equivalent of barium with one equivalent of oxygen.

But if the compound consists of one equivalent of a body, and

several equivalents of another body, then a small figure or cypher, indicating the number of equivalents, is generally placed at the foot of the symbol, and a little below; thus, the first formula in the last column of oxygenated compounds is $\text{Al}_2 \text{O}_3$, which means a compound consisting of two equivalents of aluminium, and three equivalents of oxygen (alumina). CO_2 represents one equivalent of carbon with two equivalents of oxygen, that is, carbonic acid. The formula of sulphuric acid, which consists of one equivalent of sulphur and three equivalents of oxygen, is noted SO_3 ; $\text{Fe}_2 \text{O}_3$ means sesquioxide of iron, formed of two equivalents of iron (Ferrum), and three equivalents of oxygen.

Now, when a large figure is placed at the beginning, and on the *left-hand* side of a symbol or formula, it multiplies all the equivalents which follow on the right side, until the sign $+$ appears. Thus, 2SO_3 represents two equivalents of sulphuric acid; and, therefore, the formula $2\text{SO}_3 + \text{FeO}$ means two equivalents of sulphuric acid, *plus* one equivalent of protoxyde of iron.

If we wish to represent the combination of two binary compounds, such as, for example, that of an acid with a base, the acid should be separated from the base by a comma; thus, sulphate of iron, which results from the combination of sulphuric acid SO_3 with protoxyde of iron FeO , is expressed by the following formula; FeO, SO_3 , and, therefore, the following equation, $\text{FeO} + \text{SO}_3 = \text{FeO}, \text{SO}_3$ means, one equivalent of protoxyde of iron (FeO), combined with one equivalent of sulphuric acid (SO_3), produces one equivalent of sulphate of protoxyde of iron; or, as it is usually called, protosulphate of iron (FeO, SO_3).

In the same manner,

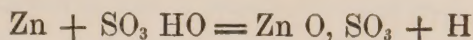
$2 \text{KO}, \text{SO}_3$ means two equivalents of sulphate of potash.

$\text{KO}, 2\text{SO}_3$ means, one equivalent of potash combined with two equivalents of sulphuric acid, or one equivalent of bisulphate of potash.

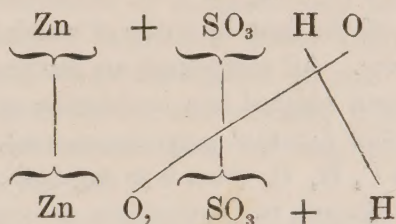
$2 (\text{KO}, 2 \text{SO}_3)$ means, two equivalents of bisulphate of potash.

Water, which is composed of one equivalent of hydrogen, and one equivalent of oxygen, is represented by HO ; and, therefore, $\text{SO}_3 \text{HO}$ means, ordinary highly concentrated sulphuric acid; that is, sulphuric acid containing one equivalent of water, or monohydrated sulphuric acid.

The following equation



means, that one equivalent of metallic zinc, having been put into hydrated sulphuric acid, the water of the sulphuric acid has been decomposed, the result being one equivalent of sulphate of oxyde of zinc, and an evolution of hydrogen gas, thus :—



The organic acids are generally represented by a dash placed over the initial letter of their symbol, thus :—

$\bar{\text{A}}$ means Acetic acid.

$\bar{\text{O}}$ „ Oxalic acid.

$\bar{\text{T}}$ „ Tartaric acid.

$\text{PbO}, \bar{\text{A}}, 3 \text{HO}$, is the formula of the neutral acetate of lead, which contains three equivalents of water.

$3 (\text{PbO}), \bar{\text{A}}$ is the formula of the tribasic acetate of lead, the figure 3 on the left multiplying the number of equivalents of oxyde of lead between parentheses.

GLOSSARY.

AFFINITY. Name of the force by virtue of which bodies of a dissimilar nature unite or combine. All compounds are the result of that force.

ALDEHYD. The term *aldehyd* is a contraction of words, which means deshydrogenated alcohol (*ALcohol DEHYDrogenatus*). In effect, the composition of aldehyd is $C_4 H_4 O_2$ (that is to say, four equivalents of carbon, four equivalents of hydrogen, two equivalents of oxygen); that of alcohol is $C_4 H_6 O_2$ (that is to say, four equivalents of carbon, six equivalents of hydrogen, two equivalents of oxygen). Aldehyd contains, therefore, two equivalents of hydrogen less than alcohol. Aldehyd is very fluid and colourless; it has a suffocating ethereal odour.

AMORPHOUS (from *ἀ, not, μορφή, form*), is said of a substance which has an irregular form; for example, a lump of chalk.

ANHYDROUS (from *ἀ, not, ὕδωρ, water*), is said of a substance which contains no water; for example, sulphate of potash, pure solid sulphuric acid, &c.

AQUA REGIA. A mixture of hydrochloric (muriatic) and of nitric acids, so called from its property of dissolving gold, which was named by alchemists *the king of the metals*.

BASE, a term generally applied to alkalies, earthy and salifiable metallic oxydes, which are looked upon as the bases of the compounds (salts), resulting from their union with acids, &c.

BLACKFLUX is made by mixing thoroughly two parts of pulverized tartar (bitartrate of potash), and one part of saltpetre (nitrate of potash), and deflagrating the mixture in successive portions in an iron ladle, or in a crucible.

BULK. See VOLUME.

CELLULOSE, name of the exterior envelopes of the cells of which the fibrous tissue of wood consists. Cellulose has the same composition as starch ($C_{12} H_{10} O_{10}$). Old linen rags, paper, elder-pith, &c., consist mostly of that substance, and Swedish filtering paper is almost pure cellulose.

CHOLESTERINE is a fatty matter which is extracted from the brain, nerves, gall, and liver; it exists also in blood and in the yolk of eggs. The biliary calculi found in the gall-bladder often consist of almost pure cholesterine. The calculi treated by boiling alcohol, and decolorized by animal charcoal, yield pure cholesterine. That which distinguishes cholesterine from all

other fatty substances is that it cannot be saponified, and that its point of fusion is very high.

CONCENTRATION is an operation by means of which the solution of a substance is reduced to a smaller bulk; this is generally done by boiling off a suitable portion of the liquid.

CONSTITUENTS, names of the individual substances of which compounds consist; thus the constituents of sulphuric acid (SO_3) are sulphur and oxygen; the constituents of sulphate of potash (KO, SO_3) are sulphuric acid and potash, or sulphur, potassium, and oxygen.

CRYSTALS (from *Κρύσταλλος*, *ice*) mineral, or saline substances, &c., which assume spontaneously a regular and determinate form. Crystal is the name of a species of glass.

CUBE, crystal which has six square and equal surfaces. Dice are cubes.

DECANTATION. When a liquid contains solid particles heavier than itself, these, ordinarily, will gradually subside to the bottom, if the whole be left at rest. The supernatant liquor may then be separated by carefully pouring it, or syphoning it off, and this is called decanting. Decantation, therefore, answers the same purpose as filtration.

DECREPITATE. A substance is said to decrepitate when, on being exposed to heat, it crackles, and flies off. A familiar illustration is offered by throwing common salt in the fire, or heating it upon a metallic plate, or in a crucible.

DELIQUESCENT (from *deliquere*, to melt, to become liquid), is said of a solid substance which gradually falls into a liquid by absorbing moisture from the atmosphere.

DEXTRINE, is the name of a species of gum into which starch is converted by heating it in an oven, and which is extensively used by calico-printers, &c., under the name of *British gum*. The penny-post stamps are all gummed on the back with dextrine. It derives its name from its effect upon polarized light, its solution turning the plane of polarization to the right.

EFFLORESCENCE (from *efflorescere*, to blossom), formation of small acicular crystals, like a fine moss or mouldiness, on the surface of bodies, which is produced by the evaporation, or loss of water, of saline substances.

ELUTRIATION (from *ἡλυτρον*, *aqueduct*), signifies to transvase, to decant from one vessel into another; by this process a mixture of heavy and of light particles may be separated from each other by stirring the mass with water and carefully decanting it, the water carries off the lighter particles, whilst the heavier parts subside to the bottom. Metallic ores are separated from their gangue in this way.

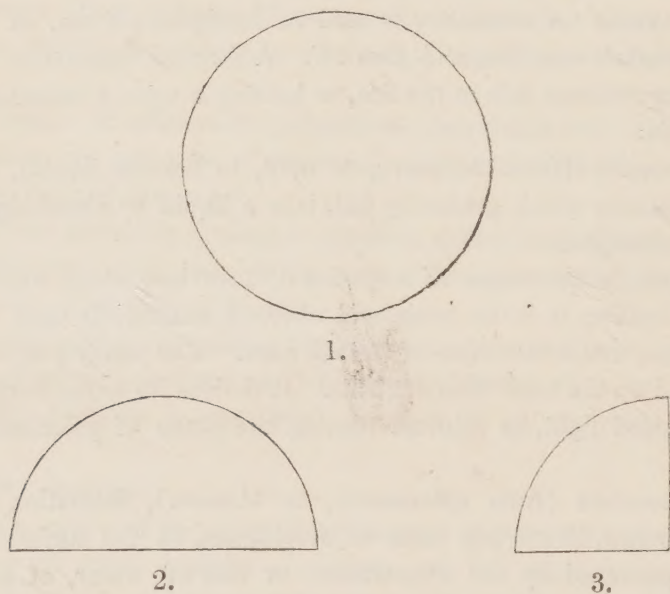
EMPYREUMATIC (from *εμπυρω*, *I burn*); name of a disagreeable and

peculiar odour produced by submitting organic substances to destructive heat in close vessels, and therefore out of the contact of the air.

EQUIVALENT (from *æquus*, equal, and *valere*, to be worth), equal in value. The term equivalent means, therefore, the numbers which represent the ponderable quantities in which substances may mutually replace each other in chemical combination.—(See the chapter on *Equivalents*, page 618.)

EUPION (from *ευ*, *well*, *πιων*, *greasy*); it is a colourless, inodorous, tasteless liquid, which is greasy, like a fixed oil, and exists abundantly in tar, especially in the animal tar obtained from the distillation of horn, bones, &c.

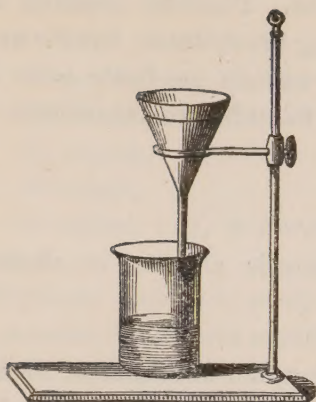
FILTER. A strainer. To filter is to strain through linen, paper, &c., or any suitable material. This is an operation of constant occurrence in analytical experiments; it consists in separating the solid particles which may be mixed up with, or suspended in a liquid; this is generally effected by cutting circular discs of good white filtering paper, of proper dimensions, fig. 1; folding each of these discs first into halves, fig. 2; and then again into quarters, fig. 3.



t has then the appearance represented in fig. 4.



* The paper filter, prepared as just said, should be put into a glass-funnel the sides of which should be at an angle of 60° , and it is advisable that the paper filter should not extend beyond the brim of the funnel, but be somewhat below it.



The funnel containing the filter is then placed in the ring, or stand here represented, or other proper support, and after previously moistening the filter with a little water, the liquor to be filtered is poured into it, the filtrate being received in a glass-beaker, or vessel, placed under the funnel in such a manner that the drops of liquid fall slantingly on the side of the vessel, in order to prevent splashing. The solid particles, of course, are retained by the filter.

GANGUE.—Portions of rock or earths which adhere to a metallic ore.

GRAVITY (SPECIFIC), is the relative weight of a body of a certain volume compared to another body of the same volume taken as a standard. It expresses, therefore, the proportion or quantity of matter contained in a body, compared with the proportion or quantity of matter contained in another body of a same bulk.

The specific gravity of solid and of liquid bodies is compared with that of pure distilled water at 60° Fahr.

One cubic foot of such water weighs 1000 ounces, and its gravity being taken as the unit or point of comparison is marked thus 1.000. When, therefore, we find the specific gravity of mercury, for example, represented by 13.58, and that of bar iron 7.788, it means that mercury is $13 \frac{58}{100}$ times, and bar iron $7 \frac{788}{1000}$ times heavier than water, or, in other words, that whilst one cubic foot of pure distilled water weighs 1000 ounces, one cubic foot of mercury weighs 13,580 ounces, and one cubic foot of iron 7,788 ounces. The method of taking the specific gravity of bodies is described in all treatises of chemistry.

HYGROSCOPIC (from *ὕγρος moist*, and *σκοπέω I watch*), means the moisture which substances absorb spontaneously from the atmosphere; the instrument by which the quantity of moisture contained in the air is approximatively ascertained is called a hygroscope.

HYDRATE (from *ὑδωρ, water*). Compounds resulting from the union of acids, of bases, or of salts with water, in fixed and determined proportions.

IGNITION signifies heating substances, such as precipitates, for example, to redness, generally for the purpose of eliminating volatile substances before weighing, but sometimes also for modifying the state of certain bodies. Ignition is carried on in the laboratory in crucibles, or capsules of platinum, of silver, or of porcelain, as the case may be. Before igniting a substance, it is necessary to dry it thoroughly first, for otherwise a projection might take place and a loss be sustained which would vitiate the analysis. The crucible or capsule used for the purpose, must, of course, be of such mate-

rial as not to be affected by the substance ignited. Platinum crucibles are in most cases preferable to any other for igniting precipitates; but the operator should bear in mind that these expensive utensils are liable to be injured or destroyed by many substances. The following directions must be attended to :—

In the dry way.

Never melt in a platinum crucible, 1. caustic alkalies, or alkaline nitrates ; consequently,

No saltpetre, caustic potash, or soda ;

Because in such a case protoxyde of platinum would be formed, of course, at the expense of the crucible, which is thereby very much attacked, and is found, after the melted mass is withdrawn, covered with indentations. The protoxyde of platinum dissolves in the alkali, and gives it a green colour.

2 No alkaline sulphurets ;

Nor sulphates mixed with charcoal powder ;

Because alkaline sulphurets act upon platinum with still greater energy than caustic alkalies.

3. No metallic substances ;

Nor any mixture which may yield a metallic residuum.*

Gold, silver, and copper, may, however, be heated red-hot in platinum crucibles without risk, provided the heat be not too near the point at which those metals fuse ; but melted LEAD cannot be poured, even in a cold platinum crucible, without spoiling it, a drop

Of LEAD ;

Of TIN, or

Of BISMUTH, falling upon a red-hot platinum vessel, invariably makes a hole in it.

4. No phosphorus, or

Phosphoric acid mixed with combustible substances, nor any mixtures which can yield phosphorus ;

Because they would form *phosphuret of platinum*, in consequence of which the crucible would be melted at that point, or would become shrivelled up.

5. Certain METALLIC OXYDES must not be heated to a white heat in platinum vessels ;

Because it often happens that at such a temperature they part with their oxygen, in consequence of which, their metal may form an alloy with the platinum, and thus damage it. The metallic oxydes which have the most tendency to become thus reduced, are the oxydes

* Such, as for example, metallic salts, containing an organic acid, or metallic oxydes with charcoal.

Of lead,
Of tin,
Of antimony,
Of bismuth,
Of copper,
Of cobalt,

Of nickel. If, however, the heat be moderate, they undergo no change.

Platinum combines easily with SILICIUM and with CARBON, wherefore, the contact of platinum crucibles with charcoal, at very high temperatures, must be avoided.

INDIGOTINE, chemically pure indigo.

INORGANIC. *See* ORGANIC.

INSPISSATE (To). To thicken a liquid containing a substance in solution, by boiling off a portion of the liquid. Vegetable extracts are inspissated juices.

LEVIGATION (from *levis*, *light*) to reduce a substance into an impalpable powder. This is done by grinding the substance, reduced to a paste with water or some other liquid, upon a flat stone or slab with a muller.

LITMUS, a blue colouring matter obtained from a species of lichen (*Lichen Rocella*). It is a most delicate test of the presence of acids.

MARSH'S APPARATUS. This apparatus is employed for the detection of arsenic by first converting it into arseniuretted hydrogen, and then decomposing that gas by heat, which then yields a deposit of metallic arsenic. The apparatus, modified by Messrs. Kæppelin and Kampman of Colmar, has been described, page 292.

MATRASS. Chemical flasks, of the form here represented.

MASS. *See* VOLUME.

METHULE (from *μεθυ*, *wine*), is a hypothetical radical derived from the transformation of the elements of wood.



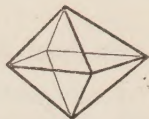
MOLECULES, exceedingly small portions of matter, of which bodies are supposed to be formed. The difference between a molecule and an atom is, that the molecule is supposed to be formed of several atoms, to the disposition or arrangement of which the molecule owes its special form.

NACREOUS is said of the lustre of mother-of-pearl, and of all substances which have that appearance.

NEUTRALIZATION. When an acid and base are made to re-act upon each other; as, for example, when soda is poured into sulphuric acid in such proportions that the liquor no longer reddens litmus paper, nor turns tur-

meric paper brown, they are said to be neutralized, and the result of the combination is a salt which, in the present instance, would be Glauber's salt (sulphate of soda).

OCTAHEDRON, crystal having eight faces. We give here the form of the regular octahedron.



ORGANIC substances belong to the vegetable, to the animal, or to the mineral kingdom. Those which belong to the animal or vegetable kingdom being organized, that is living bodies, are called *organic* bodies. The minerals, which are inert or inorganized bodies, are called inorganic bodies.

PORPHYRIZE (To). To grind upon a slab or in a mortar of porphyry, in order to reduce hard substances into an impalpable powder.

PRECIPITATE (from *precipitare, to fall down*), is the name given to substances which have been separated from their solution in a solid state. Thus, for example, if solution of sulphate of soda, or dilute sulphuric acid be added to a solution of acetate of lead, a white powder which is sulphate of lead, will fall down, or in chemical language, will be *precipitated*.

RE-AGENT, is the name given to any substance, which, in the course of a chemical analysis, may be employed to detect the presence of other substances; for example, if a little infusion, or tincture of nutgalls, be poured into a liquor containing a salt of peroxyde of iron, a purple-black colour (ink) will appear; infusion of nutgalls is therefore a re-agent for peroxyde of iron. If a drop of acid be poured into a blue solution of litmus, the solution instantly becomes red; litmus is therefore a re-agent for acids.

RETORT. Chemical vessel of the following shape—



SALIFIABLE BASES. Substances, which, by combining with acids, can form salts.

SALTS. Compounds resulting from the action of an acid upon a base (*see* BASE), or from the action of two substances on each other, one of which acting as an acid, neutralizes the other, which then acts as a base. An *acid salt* is a salt in which the acid is in excess; a *basic salt* is a salt in which the base predominates.

SOLVENT. Any substance which will dissolve another. Water is a solvent of sugar, and of a vast number of substances; ether is a solvent of

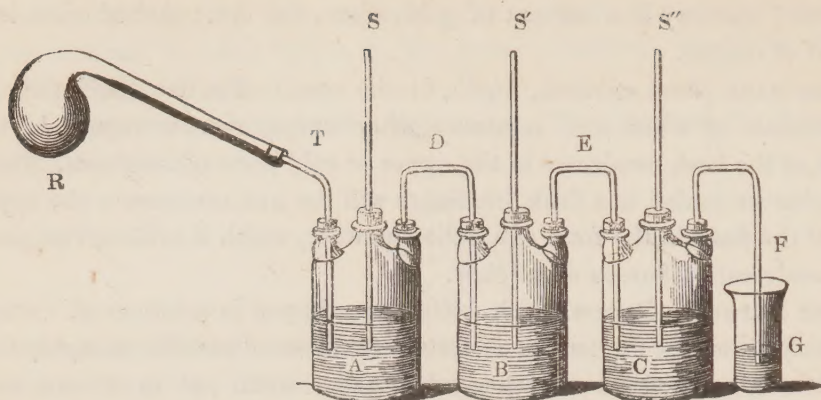
bromine ; mercury is a solvent of gold, silver, tin, &c.; melted zinc is a solvent of copper.

SUBLIMATE (from *sublimis*, *high*), is the result of a dry distillation, in consequence of which the substance, after having risen in vapour by the action of the heat, condenses in the upper or cold parts of the vessel. Thus, if sulphur be heated in a flask, the fumes will rise and condense in the upper part of the flask in the form of a yellow powder, which is sublimed sulphur, commonly called flowers of sulphur.

TEST PAPERS. Papers which have been dipped in solutions of certain vegetable colouring matters, or of certain solutions of metallic salts, capable of assuming a distinctive or characteristic colour when put in contact with other substances for which they are used as a test of their presence. Thus, paper tinged blue with tincture or with aqueous solution of litmus, turns red when put in contact with acids. Paper tinged yellow with the solution of turmeric turns brown by contact with alkalies. Paper dipped in solution of red cabbage, is gray, but it turns bright red by contact with acids, and bright green by contact with alkalies. Paper which has been immersed in solution of acetate of lead, turns black by contact with sulphuretted hydrogen. Paper which has been immersed in solution of ferrocyanuret of potassium, turns blue by contact with a solution of a salt of iron. Paper dipped in solution of ferricyanuret of potassium turns blue by contact with a solution of a protosalt of iron, but is not altered by one of a persalt of iron, &c., &c.

VOLUME, is the name given to the space occupied by the pores and molecules of which bodies consist. It is important not to confound the *mass* of a body with its *bulk* or *volume*. The term volume refers only to the dimensions of the body, and it always expresses the place which the body occupies in space. The density or gravity of a body is more or less considerable in proportion as the matter of the body is more or less compact which determines its weight. The *mass* of a body, however, depends, at the same time, upon its volume and its density, and is represented by the weight. Two bodies of the same weight have necessarily the same mass. A pound of lead has the same mass as a pound of cork or of down ; but cork and down being much less dense than lead, are much larger in bulk or volume than the latter.

WOOLFE'S APPARATUS. From the name of the inventor, is an apparatus which consists of several tubulated vessels, for the purpose of facilitating the absorption of gases by liquids. These flasks, or vessels, are so disposed and connected by air-tight tubes, that the gas which has not been absorbed by the liquid contained in the first flask, traverses that contained in the second, and then that of the third, and so on. We represent the apparatus here :—



R is the retort from which the gas to be absorbed is disengaged, and is connected with the bottles A, B, C, as represented. A, B, C, being bottles with three tubulars or openings, fitted with perfectly air-tight corks, which are perforated for the admission of the various tubes. The bottles A and B, B and C, are connected together by tubes of glass, or partly of glass and of vulcanized, or of ordinary caoutchouc at D and E. The straight tubes S, S', S'', are safety tubes, the object of which is to prevent absorption. The tube T, D, E, should only dip a very short distance into the liquor in the bottles, otherwise the first bottle would have to bear a more or less considerable pressure, which might force the corks out. Suppose, in effect, that the said tubes, T, D, E, F, were to plunge into the liquid of their respective bottles, the first $\frac{1}{8}$ of an inch, the second $\frac{2}{8}$ of an inch, and the third $\frac{3}{8}$ of an inch; and lastly, that the tube F plunges $\frac{4}{8}$ or $\frac{1}{2}$ of an inch deep into the liquid of the glass-beaker G. It is easily conceived that the pressure would be equal to the weight of a column of liquid $\frac{1}{2}$ inch high, in the beaker G; $\frac{4}{8} + \frac{3}{8}$, or the weight of a column of liquid, $\frac{7}{8}$ of an inch high in bottle C; $\frac{4}{8} + \frac{3}{8} + \frac{2}{8}$, or $\frac{9}{8}$ of an inch pressure in bottle B; $\frac{4}{8} + \frac{3}{8} + \frac{2}{8} + \frac{1}{8} = \frac{10}{8}$, that is $1\frac{1}{4}$ inch pressure in the first bottle. Wherefore, if a great number of bottles were used, it is necessary to take care that the tubes only reach a short depth down into the liquid of the bottles or jars.

THE END.

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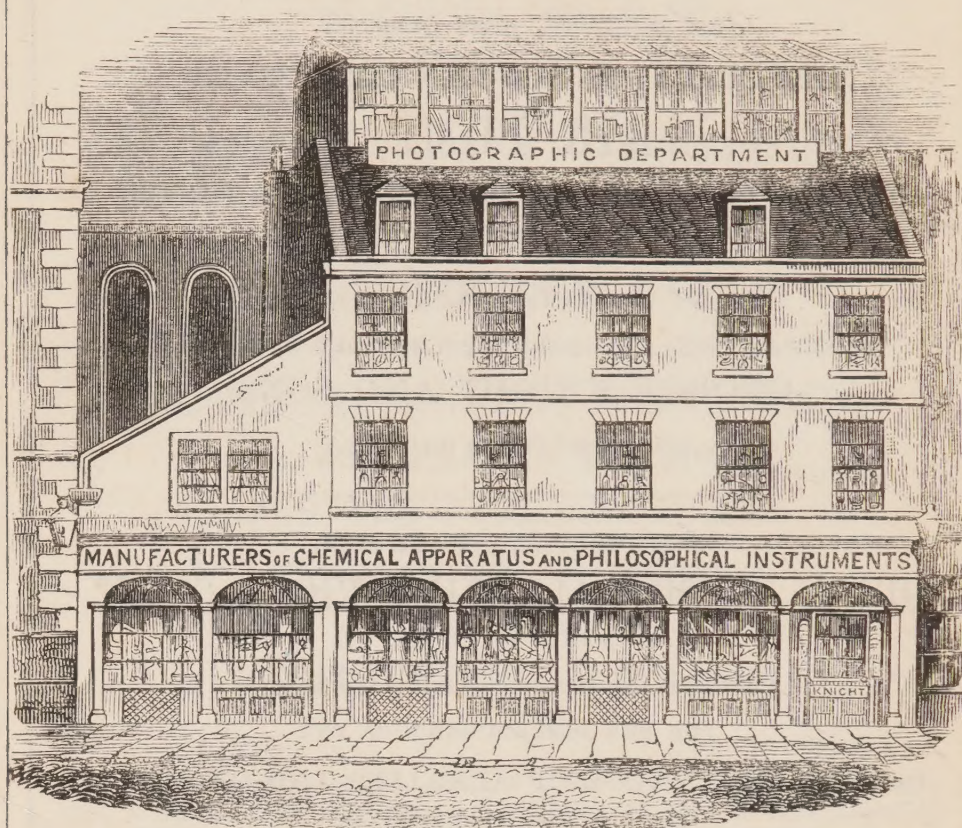
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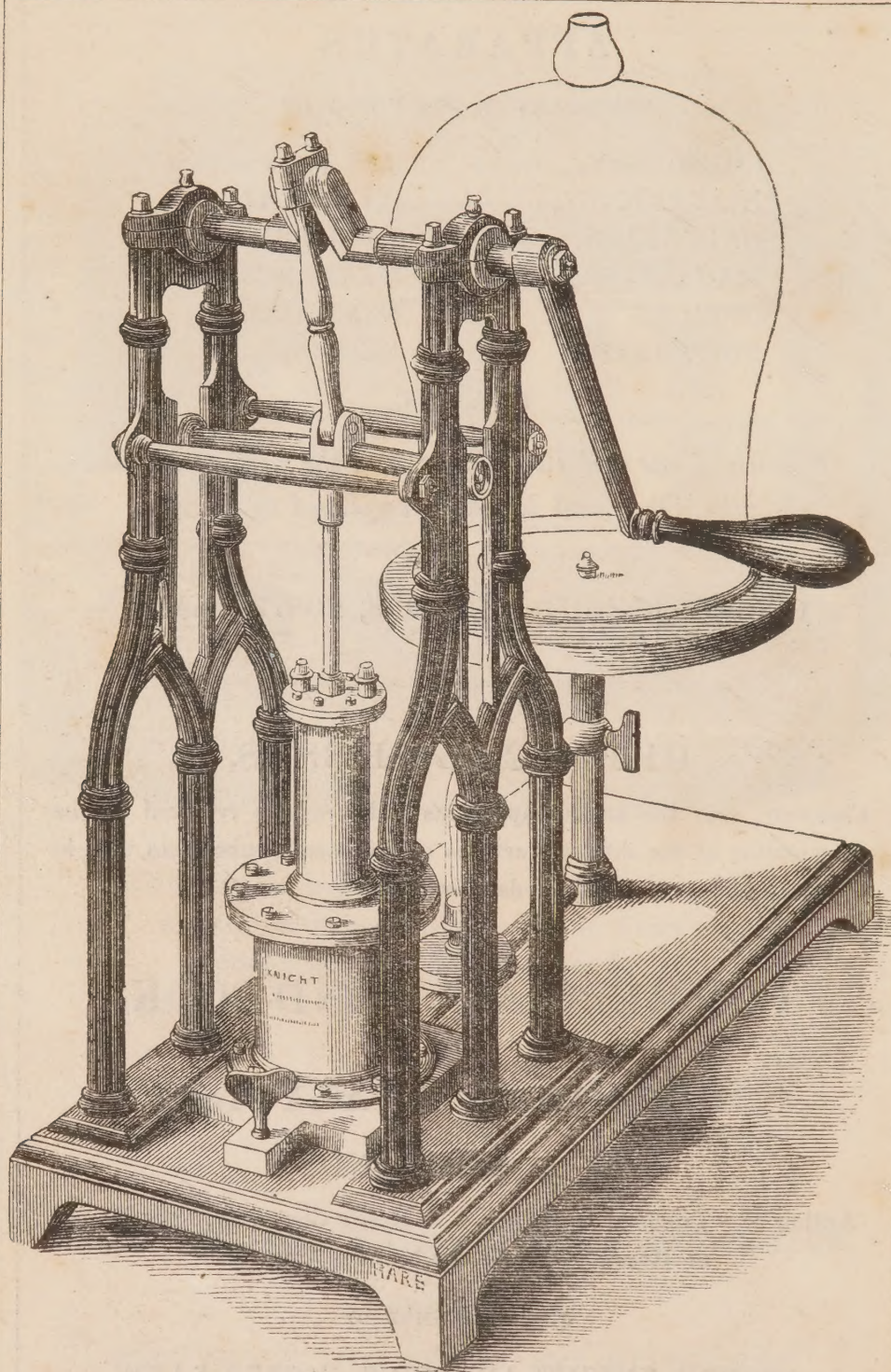
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